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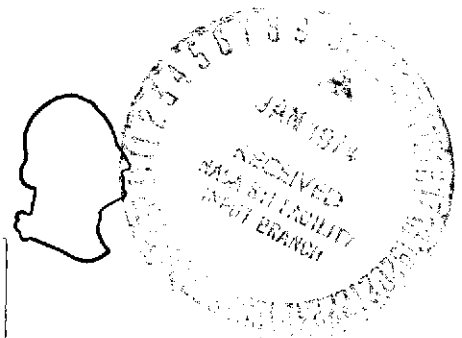
Michael Boretsky

U. S. TECHNOLOGY: TRENDS AND POLICY ISSUES

October 1973

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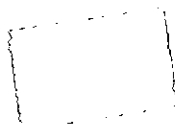


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by
Michael Boretsky
U.S. Department of Commerce

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(PRELIMINARY)

This is a revised, but still preliminary version of a paper presented March 28, 1973 to a seminar on "U.S. National Goals and Technological Strategy." This publication is intended primarily as a means of facilitating discussion of the details of the argument present herein. The seminar is sponsored by the Graduate Program in Science, Technology and Public Policy of The George Washington University and is supported by funds from NSF Grant GS-34902.

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U.S. TECHNOLOGY: TRENDS AND POLICY ISSUES *

BY

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U.S. Department of Commerce

INTRODUCTION

In the last two years much has been written and said about the role of technology in our society and how technology may be made a more effective tool for achieving some of society's most fundamental goals. In these writings and discussions, unlike in the past two decades, the concern has almost exclusively been with technology relevant to the quality of life of our society and commercial markets at home and abroad rather than technology for defense or the conquest of space.

However, in these discussions there still seems to be considerable confusion as to real state of affairs in U.S. technology, and an almost unbelievable amount of confusion as to what are the problems, the reasons for the problems, and what can be done as well as what should be done about them. As far as I can judge the reasons for the confusion arise from the narrow-disciplinary approaches to the subject on the part of participants in the debate, and, even more importantly, the "ad hocally" compiled and hardly

*The views expressed in this paper, based on a study of interest to and sponsored by the Department of Commerce, are those of the author and do not necessarily represent the views of the Department or any other agency of the U.S. Government. In the study the author was assisted by Robert McKibben.

thought-through information used by these participants. Most of the participants in this debate are either professionals in "exact" science/engineering disciplines, or "pure" economists, or "management experts." To most science/engineering professionals, the advance in technology would seem to be an end in itself, and in many cases this is the case irrespective of whether or not they preface their analysis with a caveat that it is not an end in itself (which recently they increasingly tend to do). Also, many of these people believe that the only way the Government can effectively enhance the U.S.'s technological advance is by exactly specifying the objective and providing the money to carry out the objective--the type of reasoning that invariably leads to proposals for a NASA-type of operation irrespective of the objective. To most economists, in turn, technology is one of many tools that society might use to achieve the same ends; civilian technology is essentially of concern to individual business firms and a datum to national policy makers (hence, it is usually defined only as a residual in the context of national productivity analysis); and the technological advance of the country is achievable by policies aimed at objectives other than technology itself. To most "management experts," finally, the issues of technology would seem to be on par with a myriad of other issues facing society and the Government, such as the issue of poverty and equal employment opportunity, student unrest, drug-abuse problem, public works problem, airline high-jacking, etc. So, in views of these "experts," why should society, in general, and the Government in particular, have a greater interest in technology than in all other problems?

In this paper I shall try to give a broad but factual and systematic analysis of the current state of affairs in U.S. technology, focusing especially on the problems it faces and the Government's current posture in the matter. In conclusion I shall outline the contents of what I believe are the country's needs--a comprehensive national technological policy, as well as discuss some of the options that eventually--in my opinion--will have to be used if the problems are to be dealt with in a serious manner. Hopefully, this effort will elevate the debate of the issues in question to a higher and more coherent intellectual level which, in time, might lead to a solution of the problems at hand.

As will become apparent in a moment, the reasoning I pursue in my analysis does not resemble that of a typical professional scientist/engineer, nor that of "pure" economist, nor that of a "management expert." I would describe my approach to the subject matter simply as that of a political economist, in a classical sense of the term. The essence of this approach is that I do not assume technology to be an end in itself nor as a residual result of policies aimed at objectives other than technology. Also: if technology is found to be a uniquely important tool to achieve certain social goals, my judgment would be that Government has at least as much responsibility for the relevant state affairs as private business.

In concluding these introductory remarks I should also like to note that some of the issues I discuss might be regarded by some

readers as highly controversial. A "good" bureaucrat would probably find ways to avoid these issues, but to me avoiding these issues is an ostrich-type solution to the whole problem. Consequently I shall faithfully report what my analysis suggests, and as candidly as I can. Before plunging into my analysis, however, I should like to emphatically reiterate the footnote disclaimer appearing on page one, namely, that the discussion which I offer represents my own views and under no circumstances should it be construed to represent the views of the Department of Commerce or any other agency of the Government.

I. CURRENT STATE OF U.S. TECHNOLOGY

Defining the state of a country's technology at any single point in time is obviously a very difficult task. To do this properly, we need a certain standard or standards of reference and a meaningful set of indicators since there is no single indicator that would be adequate. The most logical standards of reference for this purpose are the country's own historical performance and the state of relevant affairs abroad.

In reference to "historical standard" there is no doubt that the current level of U.S. technological development is higher than it has ever been. This statement in itself might be trivial, but not as useless as it might appear, especially if it could be amplified with some measures of how much and relative to what time. Meaningful measures that would furnish this amplification, especially at the macro level, are hard to come by, but not entirely absent. For example, in 1971 U.S. consumption of BTU's for productive purposes per civilian person employed, which is probably the single most comprehensive indicator of overall relative technological advancement, or at least relative technological intensity, that we have was about 57 percent

higher than in 1950 (1950 = 100, 1971 = 157), and the output (GNP in constant prices) per civilian person employed was 55 percent higher.¹

All meaningful indicators also show that at this time U.S. technology is still much more advanced or at least much more intensive than technology of any other country. For as open economy as the U.S. economy is today, this is, of course, extremely important. Without reciting a mass of statistics to this effect, the six indicators noted below leave no doubt that this is unquestionably the case:

(1) As recently as 1969, U.S. consumption of energy other than human and animal (BTU's) for productive purposes per civilian person employed was:

- 2.7 times as high as in France,
- 2.2 times as high as in West Germany,
- 2.0 times as high as in the United Kingdom,
- 4.8 times as high as in Japan, and
- 3.2 times as high as in the USSR.

¹The reason for this apparently close correlation between these two indicators is that historically (at least to date) the essence of most innovations in civilian technology has been the substitution, usually in all kinds of equipment and mechanical implements, of BTU's for human and animal energy. The ratio between the two figures, almost 1 to 1, however, might exaggerate somewhat the true dependence of the output per man on the consumption of BTU's per man (and, hence, technological innovations) because there are other factors that affect output per man, but it is undoubtedly very high.

The disparities between the U.S. output per civilian person employed and that of the other countries in that year were not identical with the disparities in consumption of BTU's,² but not totally dissimilar. Indeed, in 1969 the U.S. output (GNP) per civilian person employed in the economy was approximately:

- 1.6 times as high as in France,
- 2.0 times as high as in West Germany,
- 2.2 times as high as in the United Kingdom,
- 2.9 times as high as in Japan, and
- 3.5 times as high as in the USSR.

(2) Our higher level of technological development is also indicated by our exports of technology-intensive manufactured products³ as a percent of the total exports of manufactures. In 1969, for example, our exports of these products represented about 76 percent of all exports of manufactures, compared with about 58 percent in France, 67 percent in West Germany, 62 percent in the United Kingdom, and about 51 percent in Japan.

²These cannot be identical because of differences in BTU composition, differences in overall structure among the economies and differences in the relative importance of factors other than technology that affect output per man. The decisive impact of the relative intensity of technology on the overall disparities in output in these international comparisons, however, is also more than apparent.

³For the definition of "technology-intensive" manufactured products, see page 25 below.

(3) The higher level of U.S. technological development is also indicated by the relative speed with which the transportation process--of freight and passengers--is being performed in the United States relative to other countries. I estimate that in the United States an average transportation act (of freight or passengers) is performed at least 2 times as fast as in Western Europe despite the vastly greater territory to be covered, and at least 4 times as fast as in the USSR.

(4) The substantially higher level of U.S. technological development is also clearly evident in the field of communications. Our communications system is unquestionably most "comprehensive," most extensive, most automated, and fastest.

(5) Though our space program has still little relevance for the quality of our life on earth, we are the only country that has made several manned trips to the moon and back.

(6) Finally, the substantially higher level of U.S. technological advancement is also at least implicit in the fact that our industries' receipts for technological royalties and license fees from foreign countries are about 8 times as great as their payments (see Table 19 and Chart 3 below).

II. THE PROBLEMS

The situation in U.S. technology as described in the preceding section might be considered as still extremely favorable by most Americans, and enviable by most foreigners. However, U.S. technology faces many serious problems.

Lagging Productivity Growth

The problem I must focus on first is lagging productivity growth. The situation is described in Tables 1 and 2 and Chart 1. Table 1 provides estimates of comparative rates of growth of GNP per civilian person employed in the U.S. vis-a-vis other countries in selected periods over a span of over one hundred years--between 1870 and 1971. Estimates of growth in GNP per person employed are crude, but they are the most comprehensive and meaningful indicators of international disparities in productivity performance that are available for such a long period of time; Table 2, gives estimates of the approximate comparative level of the value of GNP per person employed in the same countries at selected points in time over the same hundred years and a projection of what these comparative levels are likely to be by 1985; and Chart 1 renders a graphical representation of selected estimates given in Table 2.

Viewing the figures in the two tables from the point of view of U.S. historical performance we should note, first of all, that for about 20 years following World War II the United States maintained

TABLE 1. COMPARATIVE RATE OF GROWTH IN GNP PER CIVILIAN
PERSON EMPLOYED, % PER YEAR, SELECTED PERIODS, 1870-1971

| Country | 1870-1950 | 1950-1965 | 1965-1971 |
|---|---------------|-----------|-----------|
| United States | 2.4 | 2.5 | 1.3 |
| France | 1.7 | 4.6 | 4.9 |
| West Germany | 1.6 | 4.8 | 4.3 |
| Belgium | 1.6 | 3.0 | 3.7 |
| Netherlands | 1.1 | 3.7 | 4.7 |
| Italy | 1.5 | 5.5 | 5.7 |
| United Kingdom | 1.6 | 2.2 | 2.5 |
| <u>Unweighted Average for the</u> <u>6 West European</u> | | | |
| <u>Countries</u> | 1.5 | 4.0 | 4.3 |
| USSR (Russia) | 1.7 <u>a/</u> | 4.2 | 4.3 |
| Japan | 1.4 <u>a/</u> | 6.8 | 9.6 |

a/ Growth in per capita GNP.

Sources: See Table 2

TABLE 2. APPROXIMATE COMPARATIVE LEVEL OF GNP PER CIVILIAN PERSON EMPLOYED,^{b/} SELECTED YEARS 1870-1970 AND PROJECTION FOR 1985

| U.S. = 100 | | | | | | |
|--|------------------|------|------|------|------|------------------------------------|
| Country | 1870 | 1900 | 1950 | 1965 | 1970 | 1985 (Projection) ^{c/} |
| United States | 100 | 100 | 100 | 100 | 100 | 100 |
| France | 66 | 53 | 37 | 50 | 60 | 87 |
| West Germany | 65 | 50 | 34 | 47 | 55 | 75 |
| Belgium | 100 | 78 | 52 | 55 | 63 | 79 |
| Netherlands | 132 | 89 | 46 | 55 | 66 | 88 |
| Italy | 46 | 35 | 22 | 34 | 44 | 78 |
| United Kingdom, | 90 | 70 | 47 | 45 | 48 | 54 |
| <u>Unweighted Average</u> <u>for the 6 West</u> | | | | | | |
| European Countries | 85 | 63 | 40 | 48 | 56 | 77 |
| USSR (Russia) | 45 ^{a/} | 36 | 25 | 32 | 38 | 50 |
| Japan | 27 ^{a/} | 20 | 12 | 22 | 35 | 70 |

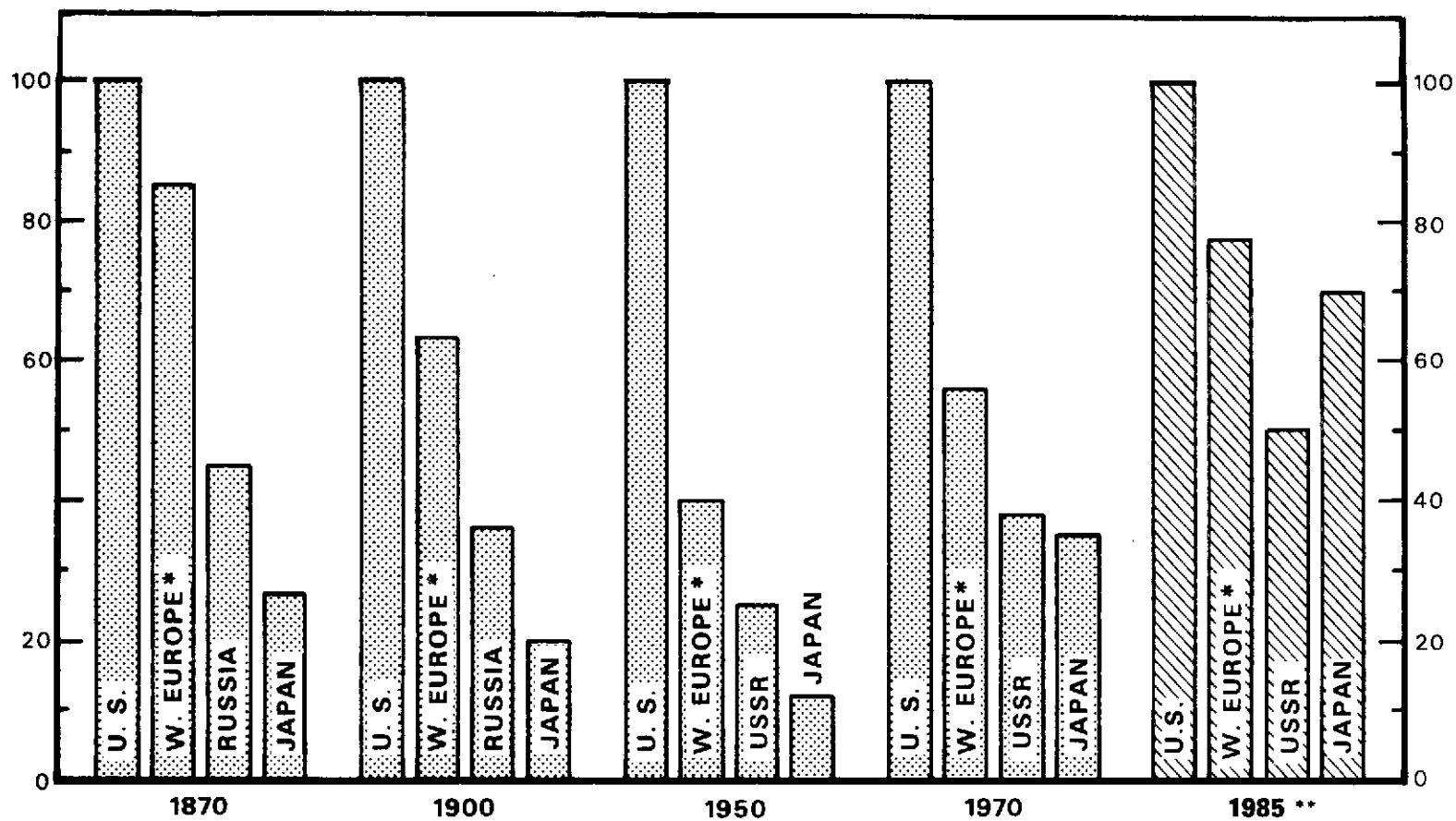
^{a/} Estimate based on relative growth of per capita GNP in 1870-1950.

^{b/} In dollars of roughly comparable purchasing power.

^{c/} The projection assumes that in the 1971-1985 period the U.S. growth in GNP per civilian person employed will average about 2 percent per year, or some 17 percent lower than the past long-term average; that of the six West European countries and the USSR will grow at about the same rate as in the 1950-1971 period, and that of Japan will grow at a rate some 25 percent smaller than in the 1950-1971 period.

Sources: U.N.; OECD; Angus Maddison, Economic Growth in the West, The Twentieth Century Fund, 1964; Idem, "Comparative Productivity Levels in the Developed Countries," Banca Nazionale del Lavoro Quarterly Review, No. 83, December 1967; Edward F. Denison, Why Growth Rates Differ, The Brookings Institution, 1967; M. Bornstein, A Comparison of Soviet and the U.S. National Product, JEC, 1959; Peter G. Peterson, Secretary of Commerce, U.S.-Soviet Commercial Relationships in A New Era, August 1972; Murray Feshbach, "Manpower in the USSR: A Survey of Recent Trends and Prospects," New Directions in the Soviet Economy, Part III, Joint Economic Committee, 1966, and subsequent communications; and individual country data.

Chart 1. Comparative Output (GNP) Per Civilian Person Employed, 1870-1985



*Average of France, West Germany, Belgium, Netherlands, Italy and United Kingdom.

** Projected

Source: Table 2

about the same rate of productivity growth as the average of the preceding 80-plus years (2.4 to 2.5 percent per year) and this greatly contributed to the United States becoming the world's foremost economic power. In the 1965-1971 period, however, our growth rate slipped to about one-half of this long-term average. Most economists argue that this decline is strictly cyclical, induced by restraints of the growth in output by policy measures in 1969 and 1970, and that the long-term growth rate in productivity will resume once the growth in output resumes its normal path. As William D. Nordhaus⁴ has recently demonstrated, however, there are good reasons to believe that this slowdown contains a substantial secular element. The most persuasive prima facie observation favoring the Nordhaus argument is the fact that no overall slowdown in U.S. history, for which we have statistics, including the "great depression" (1929-1939), reduced productivity growth by more than 20 percent of the long-term average, compared with about 50 percent in this 6-year period, most of which was not recessionary. This, of course, implies that the future rate of growth in U.S. productivity is likely to be below the long-term average, perhaps appreciably so.

Moreover, even a resumption of the long-term rate, however impressive it had been by past international standards, would

⁴Cf., William D. Nordhaus, "The Recent Productivity Slowdown," Brookings Papers on Economic Activity, 1972, #3, pp. 493-536.

not be impressive and far from sufficient for the country's comfort in the years to come. As is evident in Table 2 the United States gained the peak of its economic preeminence in the world (implicit in the relative output per man) by 1950, or thereabout, largely because its productivity growth in the preceding 80-plus years was a mere 9/10 of one percentage point higher than the average abroad (2.4 percent in the United States versus about 1.5 percent abroad). Continuation of essentially the same rate in the 1950-1965 period, however, produced a decline in the relative position of the United States vis-a-vis the other countries at the rate about the same as the rate of our gain in 1870-1950 because the other countries more than tripled their rate of growth. The decline in U.S. productivity growth to about 1.3 percent per year in the 1965-1971 period, coupled with a further speed up of this growth abroad, accelerated the United States losing its position of eminence at a rate more than 2 1/2 times as fast as it took to obtain the preeminent position in the years prior to 1950, and by 1970 the U.S. position relative to the aggregate of the other countries was already lower than at the turn of the century (see chart 1). By 1985 it is likely to be lower than it most probably was at the middle of the 19th century. As noted in Table 2, this projection assumes that in 1971-1985 U.S. rate of growth (in output per man) will be about 50 percent better than in the 1965-1971 period (2.0 percent versus 1.3 percent), Japan's will be about one-third lower, and that of the other countries will continue to be about the same as in the 1950-1971 period.

These differential trends clearly have technological implications. As I argued earlier, largely on the basis of the crude comparisons of consumption of BTU's and output per man, the principal force behind any country's productivity growth is its progress in technology. This is

in line with the conclusions of Salter's study,⁵ and the same conclusion is inferrible from more detailed studies, most notably Edward F. Denison's studies of the sources of economic growth (and sources of productivity growth as well) in the United States and selected European countries. Indeed, based on Denison's detailed calculations I estimate that in the 1929-1962 period, the period covered by his two studies, technological progress was responsible for at least two-thirds of the total growth in U.S. productivity.⁶ There is no reason a priori to believe that this contribution was any smaller in either the preceding or succeeding periods. The decline in U.S. productivity growth in the 1965-1971 period might, therefore, be at least partially attributable to a decline in overall rate of U.S. technological progress in that period relative

⁵ Cf., W.E.G. Salter, Productivity and Technical Change. Monograph 6. Cambridge, England: Cambridge University Press, 1960, passim.

⁶ In his studies Denison identifies such sources of productivity growth as changes in age-sex composition of the labor force, increased experience and better utilization of women workers, decrease in restrictions against the optimum use of resources, reduced waste of labor in agriculture, industry shifts from agriculture, education, economies of scale and a residual which he labels as "advances of knowledge." While technology as such is not identified as a source of productivity growth, one might safely assume that advances of knowledge, education and economies of scale are not independent sources of productivity growth, but work exclusively or almost exclusively through improvements in technology. According to Denison's calculations, these three factors contributed 65 percent of the total growth in national income per person employed in 1929-1957, and 72 percent in 1950-1962. Cf., Edward F. Denison, The Sources of Economic Growth in the United States and the Alternatives Before Us, CED, 1962, p. 265, and Why Growth Rates Differ, The Brookings Institution, 1967, p. 298.

to the preceding long-term average; and there can hardly be any doubt whatever that the slower growth in productivity in the United States than in the other countries since about 1950 was a reflection of any thing other than the slower rate of U.S. technological progress throughout the entire post World War II period.⁷

⁷As I suggested in one of my earlier studies (see "Comparative Progress in Technology, Productivity and Economic Efficiency: USSR Versus U.S.A." in the Joint Economic Committee's New Directions in the Soviet Economy, 1966, Vol. II-A, pp. 133-256), a country's overall rate of technological progress is also inferable from trends in key direct indicators of technological change (such as the substitution of oil and gas for coal; substitution of motor vehicles and aircraft for railroads and water barges in transportation; automation of industrial processes; mechanization and automation of material handling operations; mechanization and "chemicalization" of agriculture; substitution of synthetic raw materials for "natural" materials; computerization of data processing; etc.). I have not been able to update this study in a systematic way, but based on a rather crude tracing of the trends in most of these indicators it appears to me that in the 1965-1970 period the pre-1965 trend continued more or less unabated only in the computerization and mechanization of data and paper processing. The rate in most other "key" changes was appreciably slower than it was before 1965. Inasmuch as the computerization and other devices of data and paper processing affect only about one-third of total employment, the smaller rate of change in other "key" indicators is consistent with a slowdown in the overall rate of productivity growth. Moreover, so far the computerization, xeroxing, etc., would not seem to have been very effective in raising the output per person employed even in the operations in which the bulk of these devices are used. I estimated that in the 1961-1970 period output per average nonsupervisory and production employee employed in the private economy grew at an average rate of 1.8 percent per year, whereas output per average of managerial, clerical and sales personnel--the operations subject to the impact of computers, xerox machines, etc.--grew at an average rate of only 0.5 percent per year.

Deterioration in U.S. Trade Position

The second problem with clear-cut implications for U.S. technology, and, in my judgment, second to none, is the deterioration in the U.S. trade position. Because of the deeply imbedded Ricardian and Haberlerian theoretical reasoning regarding factors affecting U.S. trade on the part of many U.S. economists, and people who rely on their judgments, the problems of U.S. technology apparent in the deteriorating U.S. trade position in recent years are not as readily communicable as the problems implicit in lagging productivity growth, but, in my judgment, the "trade-embodied" aspect of these problems is as tangible, if not more so, if one looks at the matter in a proper way. I shall try first, therefore, to explain briefly how I or, perhaps, how one should look at the matter and then proceed with the analysis of the situation.

Following Ricardo and Haberler most economists assume that a country's foreign trade is largely a function of its comparative costs (and in this they refer to differences between costs of different commodities within the same country rather than differences between costs of the same commodities in different countries) and the intrinsic "goodness" of its foreign commercial policies. In this theory technology affects a country's foreign trade only through productivity's impact on comparative costs.⁸ As an intellectual

⁸Cf., Haberler, G. The Theory of International Trade With Its Application to Commercial Policy. Translated by Alfred Stonier and Frederick Benham, Chapter XII (William Hodge & Co., Ltd., London, 1936); and "Some Problems in the Pure Theory of International Trade," Economic Journal, Vol. LX, No. 2 (June 1950), pp. 223-40.

creation this theory is a "beauty," but its power to explain the international trade development in the real world is nil if not negative. For at least the past fifty-five years, therefore, many economists have tried to develop a more realistic theory, but so far their efforts have not met with success.⁹

To me, a country's foreign trade must be assumed to be primarily determined by:

1. The country's endowment with natural resources relative to its needs. Other things being equal, the more abundant a country's resources relative to its needs, the more of these resources it is likely to export and the fewer it will import;

2. The price levels of its products relative to such price levels in other countries, all valued in currency commonly used in international trade transactions (currently, this is the U.S. dollar, even in the Eastern Block countries). Other things being equal, the lower the country's relative price levels, the more products it will be able to export and the fewer it will import; and

⁹Regarding this effort I largely refer to studies by E. Hecksher ("The Effect of Foreign Trade on the Distribution of Income," Economisk Tidskrift, Vol. XXI, 1919, pp. 479-512) and Bertil Ohlin (Interregional and International Trade, Harvard University Press, Cambridge, Massachusetts, 1933). In my judgment of considerable importance in this effort were also studies by M.V. Posner ("International Trade and Technical Change," Oxford Economic Papers, Vol. 13, 1961, pp. 323-341); G.C. Hufbauer (Synthetic Materials and the Theory of International Trade, Harvard University Press, Cambridge, Massachusetts, 1966); D.B. Keesing ("The Impact of Research and Development on United States Trade," Journal of Political Economy, Vol. 75, 1967, No. 1, pp. 38-48); and by W. Gruber, D. Mehta and R. Vernon ("The R & D Factor in International Trade and International Investment of United States Industries," Journal of Political Economy, Vol. 75, 1967, No. 1, pp. 20-37).

3. The comparative quality and scope of the country's technological know-how embodied in its manufactured products other than that working through relative productivity and relative prices. For the kind of know-how I have in mind, I refer to, e.g., the Boeing 747 aircraft. The United States enjoys substantial surpluses in the trade related to this aircraft because the quality of U.S. know-how in this product line is superior to that possessed by other countries. The scope of this know-how (that is, number of product lines in question) is probably equally or more important than its quality.

Consistent with the comprehensive definition of technology and technological innovations,¹⁰ I equate the relative quality of this

¹⁰ The term "technology" is defined comprehensively as the way we do things, and if reference is to "production technology"--as methods of processing raw materials into semifabricates and/or final products; and technological innovations--as improvements in technology permitting either the production of products and/or services with a lower cost than before or the production of products and/or services that were impossible or impractical to produce before. Technological innovations might be "economic" (carrying a price tag) or "noneconomic" (price free). The best example of a recent major "economic" (carrying price tag) technological innovation is the communication satellite which permits live and practically instant communications around the world. Without these satellites the U.S. TV networks would have found it impossible or highly impractical (prohibitively expensive) to report instantaneously either President Nixon's visit to China or the Olympic games in Munich. A good example of a "noneconomic" (price free) innovation, in turn, is, of course, the wide-bodied transcontinental commercial aircraft, such as Boeing 747. The operating efficiency of this aircraft is about 20 to 30 percent higher (total cost, including depreciation of the equipment, per seat-mile lower by that much) than the regular-bodied aircraft, such as the Boeing 707, that was used for the purpose prior to the introduction of the wide-bodied aircraft. And the "continuous path" numerically controlled (N/C) machine tools represent an innovation embodying both economic and noneconomic features. Without these machine tools it would be impossible or prohibitively expensive to produce such products as contemporary jet engines or helicopters and the use of these machine tools in place of conventional machine tools in production of products that can be manufactured by either technology yields total cost savings of machining comparable products by 25 percent or so.

know-how with the relative advantage which users of products embodying the know-how in question derive from them--in the form of relative efficiency or ability to do things that were impossible before in the case of capital goods, and the relative satisfaction on the part of consumers in the case of consumer goods.

Thus, in contrast to the Ricardian or Haberlerian theory, my theory assumes technology, or rather technological progress, to affect a country's foreign trade in two ways:

(a) When technological improvements take the form of new or better production techniques as such, including the introduction of new or better equipment of foreign origin, the use of these techniques improves productivity, which might reduce the cost of products, thus making a country's products more competitive price wise. However, because these kinds of technological improvements work through costs and prices only, the advantage a country derives from them can be nullified not only by similar improvements in other countries but also by any development affecting relative prices, such as the failure of prices to decline with the decline in cost, tariffs, taxes, and subsidies, or changes in exchange rates. Therefore, I do not consider such technological improvements as a distinct determinant of foreign trade, although they might be crucial in maintaining or improving a country's price competitiveness.

(b) When technological improvements take the form of new or better equipment, synthetic raw materials, or even new hybrids of grains for seed, a country has something new or better to export and/or it will be in a better position to compete with imports. Although both

"economic" (carrying a price tag) and "noneconomic" (price free) improvements are important, at least in the areas of seeming international parity of know-how the latter ("noneconomic") tend to be decisive factors of competitiveness since such improvements represent a sort of surplus value to the products' users and this surplus value frequently outweighs even substantial (conventionally-defined) cost and price disadvantages which the country might have. Indeed, I am told that it is a generally known fact among U.S. manufacturers of industrial equipment that in competing for sales in the world markets with foreign competitors the greater reliability of their products in use alone, which is generally a function of virtually cost-free quality of design and quality of "craftsmanship" of production workers, frequently offsets a price disadvantage of as much as 20 percent or more. At least a priori this is not surprising because in most manufacturing industries the cost of services of capital equipment (depreciation and interest) represents a small fraction of the total cost (10 to 15 percent), but the quality, including the reliability, of the equipment used determines the productivity of all other factors used in production.

The foreign trade advantages that a country derives from comparatively higher quality of such technological know-how is generally of a monopolistic nature (it can rarely be nullified by measures other than similar know-how) and, hence, is considered as a distinct determinant of its foreign trade.

Frequently a specific technological innovation can benefit a country's foreign trade in both ways (e.g., a new or better piece of industrial equipment may be exported and its use at home may result in a more efficient production technique). Frequently such an innovation may lead to only one of these kinds of benefits (e.g., a new or better camera or piece of pollution-control equipment would generally benefit a country's foreign trade in only the second way). However, to be a distinct factor in international merchandise trade, innovations must be embodied in manufactured products, which is to say, they must be exportable. Other things being equal, the higher the level and the broader the scope of a country's know-how of this type, relative to other countries, the stronger will be its technological competitiveness and, hence, the more products it will be able to export and the fewer it will import.

In a general ("ordinary") way the importance of this type of know-how for a country's foreign trade might be best illustrated by Japan's experience. As is generally known, back in the middle of the 1950's Japan's know-how in ship building and the manufacture of automobiles, electronic products and optical devices was hardly outstanding, but by now it appears to be second to none, or second only to the United States, both in regard to relative quality as well as its scope. This change has been the essence of most if not all of the gains which Japan has scored in its foreign trade since that time and these have been simply immense.

The importance of this type of know-how has also been immense in U.S. trade. For example, based on a recent study of the National Bureau of Economic Research¹¹ we know that in the area of nonelectric machinery prices of U.S. internationally traded products in the middle 1960's were at least 10 percent higher than European prices (EEC and the United Kingdom) and at least 25 percent higher than Japanese prices, but, according to Department of Commerce data, the United States had an overall trade surplus in the trade in this product group amounting to \$4.0 billion in 1964, \$5.6 billion in 1970, and \$5.3 billion in 1971 and 1972. In the face of the stated price disadvantages, the only thing that could have produced these surpluses for the United States is the superior know-how embodied in U.S.-made products.

Unlike the relative endowment in natural resources and relative price levels, however, a country's advantage in this type of know-how might be used for the export of commodities embodying this know-how or for the export of this know-how in a "naked" form—via sales of patents and licenses. Unless the demand abroad for products embodying this know-how is infinite (in the real economic world, this can hardly ever be the case), the more this know-how is exported in a "naked" form the fewer products embodying this know-how it will be able to export and, conversely, the more of such products it might import.

¹¹Cf., Irving B. Kravis and Robert E. Lipsey, Price Competitiveness in World Trade, New York: National Bureau of Economic Research, 1971.

The quality and the scope of a country's know-how in question is a function of gradual (usually small) improvements in technology introduced over time by production engineers, technicians and skilled workers ("craftsmen"); formal (organized) R & D effort; innovative activity of "lone wolves;" and the importation of advanced technology from abroad.

Consistent with this theoretical framework, my statistical analysis uses a five-way classification of commodities traded:

1. Agricultural products. Trade in these products is presumed to be a function of the relative endowment with agricultural land and climate and the relative prices of these products. In the international trade in these products relative technological know-how rarely affects the quality of the exported products (except when new hybrids of grains for seed are involved, but these are rarely important in terms of the overall value of trade), only their cost. Consequently, I do not consider the quality of technology--as I define it--a distinct factor in the trade of agricultural products.

2. Minerals, unprocessed fuels, and other raw materials (products of nature other than agricultural land and climate). Trade in these products is largely a function of the relative endowment with natural resources and relative prices. The quality of technology, as in agricultural products, is not an independent factor (because it rarely affects the quality of the products).

3. Manufactured products regarded as not technology-intensive. This group includes all manufactured products not specified in the

fourth group described below. The most important commodities in the group are textiles and apparel, steel, nonferrous metals, paper products, furniture, glass products, etc. Trade in these products is assumed to be largely a function of relative prices. The quality of technological know-how embodied in these products other than that working through comparative prices might be of importance, but this effect is regarded more as potential than actual, because, with some exceptions, this know-how is the result of the world-wide evolution of "industrial art" over a very long period of time rather than the result of advanced engineering or a concerted R & D effort.

4. Technology-intensive manufactured products. This group includes chemicals; nonelectrical machinery; electrical machinery and apparatus, including electronics; all types of transportation equipment, including aircraft and automobiles; and scientific and professional instruments and controls. The chief criterion in designating these products as technology-intensive is the relative intensity of the new-technology-generating inputs used in their production--research and development (R & D), scientific and engineering manpower used in functions other than R & D (design, production supervision, customer services, etc.), and the relative level of skill ("craftsmanship") of workers.

For the United States, the relative intensity of these inputs used in the production of manufactured products is shown in Table 3: on the average the industries manufacturing technology-intensive products spend about 11 to 12 times as great a proportion of their

TABLE 3. RELATIVE INTENSITY IN USE OF TECHNICAL INPUTS IN U.S.
MANUFACTURING INDUSTRIES, SELECTED YEARS, 1960-1970

| Industry | A. Expenditures on R & D as % of Value Added Originated in the Industry | | B. Employment of Scientists, Engineers and Technicians in R & D as % of Production Workers | | C. Employment of Scientists, Engineers and Technicians in Functions Other than R & D as % of Production Workers | | D. Employment of Craftsmen as % of "Operatives and Laborers" | |
|--|---|--------------------|--|------|---|------|--|--------------------|
| | 1961 | 1970 | 1961 | 1970 | 1961 | 1970 | 1960 | 1970 |
| All Manufacturing Industries | 6.6 | 5.8 | 3.0 | 3.0 | 4.4 | 5.9 | 39.0 | 39.3 |
| 1. Ordnance and Missiles | 75.9 ^{a/} | 37.7 ^{a/} | 28.1 | 24.1 | 23.9 | 28.2 | N.A. | 46.4 |
| 2. Chemicals and Related Products | 7.4 | 6.5 | 10.3 | 11.0 | 12.5 | 14.5 | 42.0 | 43.5 |
| 2a. Drugs and Medicines | 7.4 | 9.3 | 14.9 | 18.5 | 17.9 | 16.2 | 34.8 | N.A. |
| 2b. All Other Chemicals | 7.5 | 5.8 | 9.7 | 10.0 | 11.8 | 14.3 | 67.6 | N.A. |
| 3. Nonelectrical Machinery | 6.3 | 5.4 | 4.7 | 3.8 | 7.7 | 9.4 | 71.6 | 57.9 |
| 3a. Office and Computing Machinery | 25.4 ^{b/} | 18.5 ^{b/} | N.A. | 15.8 | N.A. | 23.8 | 50.3 | N.A. |
| 3b. All Other Nonelec. Machinery | 3.5 ^{b/} | 2.9 ^{b/} | N.A. | 2.2 | N.A. | 7.7 | 73.9 | N.A. |
| 4. Electrical Machinery & Equipment | 17.2 | 15.6 | 10.8 | 9.3 | 10.7 | 12.3 | 35.3 | 31.0 |
| 4a. Radios, TV, Commo. Equipment & Electronics | 21.9 | 18.0 | 14.5 | 12.0 | 12.2 | 13.2 | N.A. | N.A. |
| 4b. All Other Electrical Machinery & Equipment | 13.5 | 13.0 | 6.6 | 5.9 | 9.0 | 10.1 | N.A. | N.A. |
| 5. Transportation Equipment | 27.3 | 23.0 | 6.8 | 6.7 | 6.4 | 8.5 | 66.9 | 61.5 |
| 5a. Aircraft and Parts | 38.0 ^{a/} | 38.4 ^{a/} | 9.8 | 9.6 | 7.1 | 9.1 | 87.3 | 82.2 |
| 5b. Motor Vehicles & Equipment | 5.5 ^{b/} | 7.0 ^{b/} | 2.1 | 2.7 | 3.8 | 5.5 | 43.0 | 40.1 |
| 6. Instruments & Related Products | 8.3 | 8.8 | 9.4 | 7.9 | 11.8 | 14.1 | 50.9 | N.A. |
| 7. Sum of #2-6 | 14.8 | 12.2 | 7.9 | 7.4 | 9.1 | 11.2 | 55.7 | 49.2 ^{c/} |
| 8. All Other Manufacturing Industries | 1.2 | 1.1 | 0.9 | 1.0 | 2.3 | 2.3 | 32.2 | 34.9 ^{d/} |
| 8a. Primary Metals | 1.4 | 1.2 | 1.1 | 0.7 | 4.0 | 4.1 | 60.5 | 63.7 |
| 8b. Fabricated Metal Products | 1.3 | 0.9 | 1.6 | 1.4 | 4.4 | 4.0 | 52.5 | 47.6 |
| 8c. Rubber Products | 3.5 | 2.8 | 1.5 | 1.1 | 2.8 | 3.6 | 24.5 | 25.5 |
| 8d. Textiles and Apparel | 0.2 | 0.3 | 0.1 | 0.2 | 0.2 | 0.3 | 10.9 | 14.4 |
| 8e. Paper & Allied Products | 0.9 | 1.0 | 1.0 | 1.3 | 2.8 | 2.8 | 30.0 | 32.4 |
| 8f. Food & Kindred Products | 0.6 | 0.6 | 0.3 | 0.3 | 0.6 | 0.9 | 25.5 | 23.9 |

TABLE 3. RELATIVE INTENSITY IN USE OF TECHNICAL INPUTS IN U.S.
MANUFACTURING INDUSTRIES, SELECTED YEARS, 1960-1970--Continued

- a/ Published NSF data on total R & D expenditures in the respective industries are comprehensive only for the total of aircraft, ordnance and missile industries. The estimates posted in the table are based on proratings in accordance with the relative employment of scientists, engineers, and technicians in R & D of the two industries.
- b/ Applied research and development in the respective product fields performed as a percent of the value added in the industry primarily engaged in the production of the products in question.
- c/ Net of instruments and related products. With instruments and related products the percentage would be greater.
- d/ Including instruments and related products. Without instruments and related products the percentage would be smaller.

Sources:

Expenditures on R & D: NSF, Research and Development in Industry, 1970, NSF 72-309; and Basic Research, Applied Research, and Development in Industry, 1963, NSF 66-15.

Employment of Scientists, Engineers and Technicians: 1961 -- U.S. Department of Labor, Bureau of Labor Statistics, Scientific and Technical Personnel in Industry 1961-1966, Bulletin No 1609; and 1970 -- BLS, "Scientific and Technical Personnel in Industry, 1970", published in 1972.

Employment of Craftsmen: 1960 -- U.S. Bureau of the Census, Census of Population: 1960, "Occupation by Industry," Final Report PC(2)-7C; and 1970 -- Census of Population: 1970, "Occupation by Industry" Final Report PC(2)-7C.

Employment of Production Workers: U.S. Bureau of Labor Statistics, Employment and Earnings, United States, 1909-71. Bulletin 1312-18.

Value Added in Industry: U.S. Bureau of the Census, Annual Survey of Manufactures: 1970, Industry Profiles, M 70(AS)-10; and Statistical Abstract of the United States, 1962 and 1972.

value-added on R & D as do industries manufacturing nontechnology-intensive products (compare items no. 7 and 8 of Section A of the table); the employment of scientists, engineers and technicians in functions other than R & D relative to production workers in industries manufacturing these products is almost 5 times as great as in the other manufacturing industries (Section C); and the employment of craftsmen relative to "operatives and laborers" is also some 70 percent or so greater than in the other industries (Section D).

As is evident in the table, the relative intensity of these technical inputs is not uniform in all products and to that extent the classification of some products as technology-intensive and other as nontechnology-intensive might, at least by some criteria, be somewhat arbitrary. Most notably, the inclusion of "nonelectrical machinery other than office and computing machinery" (item 3b in the table) into technology-intensive and "rubber products" (item 8c) into nontechnology-intensive might be questioned since the relative R & D inputs are about the same (2.9 and 2.8 percent of value-added, respectively, in 1970). The relative use of S & T manpower in functions other than R & D and the relative use of craftsmen, however, is much higher in the former than the latter. Moreover, the conventional statistical classification of machinery into nonelectrical and electrical tends to understate the relative R & D inputs used in manufacture of the kind of "nonelectrical" machinery that the final-demand users actually buy. We know, for example, that in numerically-controlled machine tools, which are included in nonelectrical machinery

other than office and computing machinery (item 3b), the cost of (electronic) numerical controls represents about one-third of the total cost¹² and these controls are largely produced in the electronics products industry and supplied to the machine tool industry as ready-to-use subassemblies. Indeed, today there is hardly any such thing as nonelectrical machinery as the conventional statistical term might imply. Based on Bureau of Economic Analysis input/output tables I estimate that if the R & D expenditures were compiled in terms of specific final-demand products rather than such a classification as nonelectrical and electrical machinery, etc. the relative R & D expenditures in the production of nonelectrical machinery other than office and computing machinery (item 3b) would be at least 25 percent greater than is shown in the table, but it would not be higher than is shown in "rubber products" (item 8c).¹³ Considering all of these things there can hardly be any question that the relative intensity of all the new-technology-generating inputs in the manufacture of products included in item 3b is much higher than in "rubber products" and the inclusion of the former products into the

¹²See, U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports, Series: BDSAF-630(63)-1, and Series M-35W (current).

¹³In fact, as is readily seen in the BEA input/output tables, the production process of all products included in items 3 through 6 of Table 3 is to that extent interrelated that the best way to analyze them for the purpose at hand would be to treat them as a single commodity group of "engineering products" (a term widely used in Europe).

technology-intensive category is more sensible than would be their inclusion into the not technology-intensive category.

In all probability, the relative intensity of the technical inputs used in the manufacture of these product groups as shown in Table 3 is not unique for the United States. For this we do not have all the data, at least not readily available, that would permit construction of a similar table for other countries, but the other countries' expenditures on R & D by industry strongly suggest that the situation there is not grossly dissimilar.

In 1969, for example, 78 percent of expenditures of the business enterprise sector (industry) of France were in industries manufacturing the products in question; in West Germany, 87 percent; in Italy, 76 percent; in the United Kingdom, 79 percent; in Canada, 62 percent; and in Japan, 71 percent, compared with 86 percent in the United States.¹⁴

The industries manufacturing these products, however, are not only the primary users of the new-technology-generating inputs, but they are also, unquestionably, the primary domestic originators of technological innovations, and this not only for their own use but for all other sectors of the economy through the equipment, instruments, and

¹⁴OECD, International Survey of the Resources Devoted to R & D in 1969 by OECD Member Countries. Statistical Tables and Notes. Vol. I., "Business Enterprise Sector," Table E 1(B).

synthetic materials embodying innovations they supply. Internationally, the disparities in technological prowess among the industrialized countries are largely concentrated in these industries. International trade in these products is largely a function of the quality of technological know-how embodied in them, the scope of this know-how, and the relative prices of the products, with the two former ones, most probably, being more important than the latter.¹⁵

¹⁵Since I first proposed the concept of technology-intensive and not-technology-intensive manufactured products (1970), there have been several attempts to produce a similar but a more "refined" classification (see, e.g., U.S. Tariff Commission, Implications of Multinational Firms for World Trade and Investment and for U.S. Trade and Labor, February 1973, Volume III, Chapter VI). In these attempts the sole criterion for classifying manufactured products by the intensity of technology used in their production has been the recent (1966 to 1970) R & D expenditures by individual industries per dollar value of sales or shipments relative to that of the average of the manufacturing industry as a whole. Following this criterion, the attempts in question have suggested an alternative three-way classification: "high technology," "medium technology" and "low technology" products.

Some people, though approving my classification in principle, have not been quite happy with my inclusion of automotive products into the technology-intensive category on grounds that there is "nothing special" about the technology of automobile making and that it is about the same all over the world.

Although, as is clearly shown in Table 3 and/or stated in the text, the relative intensity of technological effort in the production of products which I classify as technology-intensive is far from uniform, there is hardly any arbitrariness in what I consider as technology-intensive products or not technology-intensive: irrespective of the input criterion used in making the judgment, the average intensity of the new-technology-generating inputs used in producing technology-intensive products (especially in the "final-demand" composition) is vastly greater than in the not technology-intensive products. Moreover, my criteria are as comprehensive as one might

5. All commodities, consisting of the sum of the four groups, commodities not classified by kind, and, in the case of U.S. exports, reexports of foreign merchandise. These reexports consist of all

Footnote 15 Continued

sensibly require in a broad policy-oriented study. This is not the case with the suggested three-way classification. Indeed, I find the suggested three-way classification to have little or no analytical merit, and this for at least four reasons:

First, the suggested "refinements" lack the theoretical underpinning of the sources of technological innovations and arising therefrom a proper understanding of the concept of the intensity of technological effort. As I argue in the text, in any industry technological innovations are generated not only by formal (organized) R & D, but also by professional S & T manpower working in functions other than R & D, and skilled workers (craftsmen). Moreover, historically the latter were much more important than formal R & D both as inventors and innovators (translators of inventions into practical use). Though by now the responsibility for inventions is in most industries centered in formal (organized) R & D, there are quite a few industries where S & T manpower working outside formal R & D and skilled workers are still the prime sources of both inventions and innovations and in all industries they continue to be the only translators of inventions into practical use.

Second, R & D expenditures of an industry relative to its sales or shipments, the sole criterion for the "refined" classification, is a highly imprecise indicator of the industry's intensity of its R & D effort because of the varying degrees of multiple counting contained in the sales and/or shipments data of various industries.

Third, the suggested three-way classification ignores the interrelatedness of production of various products and that the "final-demand" composition of products actually bought by the users (or exported) is a substantially different animal than that implied in the formal statistical classification of industries. As I explicitly stated in the text, there are substantial differences between the R & D intensity of products which the users actually buy and what might be superficially inferred from the formal statistical classifications.

types of commodities. Ideally, one would want to adjust the data for the four preceding groups, either on the import side or export side, by the value of these reexports. Unfortunately, the commodity detail

Footnote 15 Continued

Finally, there is the least merit in increasing the number of commodity groups to be used in analysis, especially a policy-oriented analysis. To be precise we might wish to have as many groups as we have industries or even specific commodities but we could hardly make much analytical use of this precision. To give an analogy, J.M. Keynes undoubtedly knew of more factors affecting national income than consumption and investment, but he preferred to set forth his famous equation to read simply as Y (national income) = I (investment) plus C (consumption).

Regarding the inclusion of automotive products into the category of technology-intensive products it should suffice to note that it is strictly in accordance with the three general criteria I use in classifying all manufacturing products. As shown in Table 3, Item 5b, R & D expenditures in automotive products as percent of the value added originated in the industry manufacturing these products has been 4.6 to 6.3 times as great as the average for not technology-intensive products, the use of scientists and engineers in functions other than R & D as a percent of production workers 1.7 to 2.4 as great, and the use of craftsmen as percent of "operatives and laborers" about 1.3 as great. In addition the automobile industry commands considerable R & D and other technical inputs in supplier industries, especially in plastics, steel, nonferrous metals and machine tools. The fact that the technology of automobile manufacturing is similar all over the world is irrelevant for the definition--it only means that other countries have similar know-how. That it is not simple technology is indicated by the fact that though the Soviets produced a lunakhod (moon-rover), a world-wide marvel of precision engineering, they shop all over the world for automobile technology.

on these reexports is not available. However, the inaccuracies in the analysis of U.S. trade performance by the defined commodity group arising from this inconsistency in the data are inconsequential because the over-all value of these reexports is quite small (about 1 to 1.5 percent of total exports).

The data on what occurred in total U.S. trade and in each of the four commodity groups as defined above from the early 1950's (1951-1955) until 1972 are shown in Table 4 (dollar value of transactions), Table 5 (growth rates in exports and imports), and Chart 2.

Before drawing conclusions from these data, I should like to note three points:

(a) The beginning of the period covered in the tables, 1951-1955 (= 1953), more or less coincides with the time when the European countries and Japan completed the reconstruction of their war-ravaged economies and the United States ended the Korean war. Hence, the implications arising from trends starting at that time cannot be disputed on grounds of "starting at a low base," distortions of Korean war, etc.

(b) Throughout the entire period the rate of U.S. inflation in terms of average annual percentage increases in price indexes,

TABLE 4. TRENDS IN U.S. MERCHANDISE TRADE BY MAJOR
COMMODITY GROUP, SELECTED YEARS, 1951-1972

(Values in Billions of Dollars)

| Commodity Group | 1951-1955 (Average) | 1962 | 1965 | 1971 | 1972 |
|---|------------------------|------|------|------|-------|
| <u>Agricultural Products</u> | | | | | |
| Exports ^{b/} | 3.2 | 5.0 | 6.2 | 7.7 | 9.4 |
| Imports | 4.4 | 3.9 | 4.1 | 5.8 | 6.5 |
| Balance | -1.2 | 1.1 | 2.1 | 1.9 | 2.9 |
| <u>Minerals, fuels and other raw materials</u> | | | | | |
| Exports ^{b/} | 1.3 | 2.1 | 2.6 | 3.8 | 5.2 |
| Imports | 3.3 | 4.5 | 5.4 | 7.9 | 9.7 |
| Balance | -2.0 | -2.4 | -2.8 | -4.1 | -4.5 |
| <u>Not technology-intensive manufactured products</u> | | | | | |
| Exports ^{b/} | 3.7 | 3.5 | 4.4 | 6.3 | 6.1 |
| Imports | 1.9 | 5.1 | 7.4 | 14.6 | 17.8 |
| Balance | 1.8 | -1.6 | -3.0 | -8.3 | -11.7 |
| <u>Technology-intensive manufactured products</u> | | | | | |
| Exports ^{b/} | 6.6 | 10.2 | 13.0 | 24.2 | 26.5 |
| Imports | 0.9 | 2.5 | 3.9 | 15.9 | 19.9 |
| Balance | 5.7 | 7.7 | 9.1 | 8.3 | 6.6 |
| <u>All Commodities</u> ^{a/} | | | | | |
| Exports ^{b/} | 15.5 | 21.7 | 27.5 | 44.1 | 49.7 |
| Imports | 10.9 | 16.5 | 21.4 | 45.6 | 55.6 |
| Balance | 4.6 | 5.2 | 6.1 | -1.5 | -5.9 |

a/ Include the four commodity groups shown above plus "goods and transactions not classified according to kind" and reexports.

b/ U.S. exports include "non-commercial" shipments, such as military grant/aid, shipments of agricultural commodities under Public Law 480, etc.

Source: U.S. Department of Commerce

TABLE 5. AVERAGE ANNUAL RATES OF GROWTH IN U.S. EXPORTS AND IMPORTS IN CURRENT DOLLARS BY MAJOR COMMODITY GROUP, PERCENT PER YEAR, SELECTED PERIODS, 1951-1973

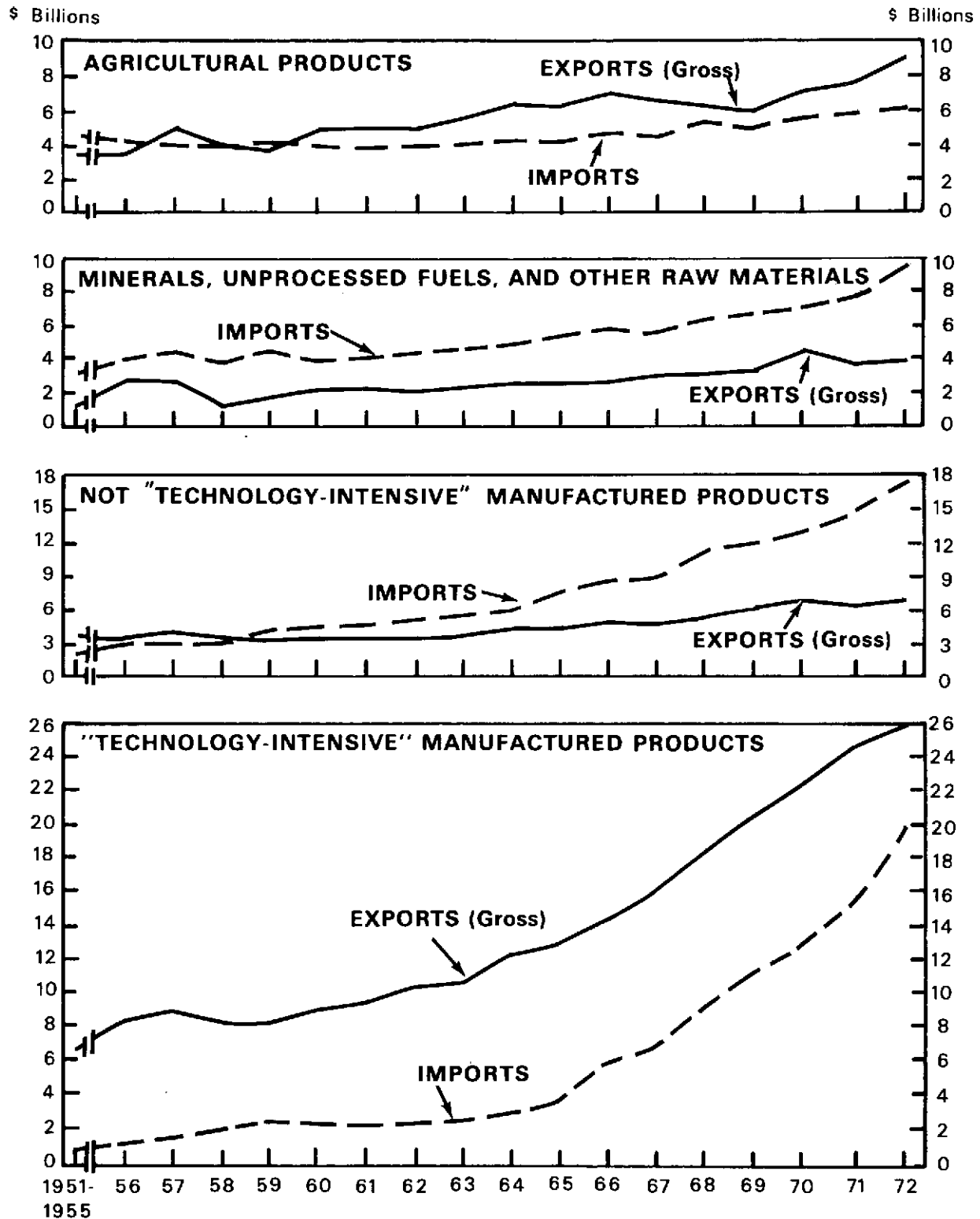
| Commodity Group | 1951-1955 to 1962 | 1962-1971 | 1971-1972 |
|---|-------------------|-----------|-----------|
| <u>Agricultural Products</u> | | | |
| Exports ^{b/} | 4.6 | 4.0 | 22.1 |
| Imports | -1.2 | 3.7 | 12.1 |
| Balance | --- | --- | --- |
| <u>Minerals, fuels and other raw materials</u> | | | |
| Exports ^{b/} | 4.9 | 5.5 | 36.8 |
| Imports | 3.2 | 5.2 | 22.8 |
| Balance | --- | --- | --- |
| <u>Not technology-intensive manufactured products</u> | | | |
| Exports ^{b/} | -0.6 | 5.5 | -3.2 |
| Imports | 10.4 | 10.0 | 21.9 |
| Balance | --- | --- | --- |
| <u>Technology-intensive manufactured products</u> | | | |
| Exports ^{b/} | 4.4 | 8.2 | 9.7 |
| Imports | 10.8 | 18.3 | 25.4 |
| Balance | --- | --- | --- |
| <u>All Commodities ^{a/}</u> | | | |
| Exports ^{b/} | 3.4 | 6.7 | 12.7 |
| Imports | 4.2 | 9.7 | 21.9 |
| Balance | --- | --- | --- |

^{a/} Include the four commodity groups shown above plus "goods and transactions not classified according to kind" and reexports.

^{b/} U.S. exports include "non-commercial" shipments, such as military grant/aid, shipments of agricultural commodities under Public Law 480, etc.

Source: U.S. Department of Commerce

**Chart 2. Trends in U.S. Trade by Major
Commodity Group, 1951-55—1972**



Source: Table 4

irrespective of the index used (except the index of unit export values, which, as BLS has demonstrated,¹⁶ is meaningless), has been substantially lower than in any other industrialized country, with the only exception being the wholesale prices of manufacturing goods in Japan in a few of the most recent years. The comparative rates of inflation in the 1960's are shown in Table 6. International Monetary Fund publications¹⁷ indicate that the rates of inflation were even more favorable for the United States in the 1950's.

(c) The data on U.S. exports, both total and by commodity group, include "noncommercial" transactions, such as shipments of grants and aid (both military and nonmilitary), sales of agricultural products for nonconvertible currencies under Public Law 480, etc., whereas imports generally reflect only commercial transactions. Hence, the trade surpluses shown in the table generally overstate the U.S. commercial trade performance and the deficits understate the true state

¹⁶Cf., U.S. Department of Labor Bulletin No. 71-363, dated June 30, 1971; and No. 72-16, dated January 14, 1972.

¹⁷See Joseph O. Adekunle, "Rates of Inflation in Industrial, Other Developed and Less Developed Countries, 1949-65," International Monetary Fund Staff Papers, Vol. XV, No. 3, November 1968, pp. 531-559.

TABLE 6. COMPARATIVE RATES OF INFLATION:^{a/}
U.S. VERSUS SELECTED EUROPEAN COUNTRIES, JAPAN AND CANADA, 1960-1972

| Indicator and Country | 1962 = 100 | | | | | | | Average Annual Rate of Change in 1960-1972, Percent |
|---|------------|------|------|------|------|------|-------|---|
| | 1960 | 1963 | 1965 | 1967 | 1969 | 1971 | 1972p | |
| 1. GNP Deflator: | | | | | | | | |
| United States | 98 | 101 | 105 | 111 | 121 | 134 | 136 | 3.0 |
| United Kingdom ^{b/} | 94 | 102 | 109 | 117 | 124 | 148 | 157 | 4.8 |
| France ^{b/} | 93 | 107 | 113 | 121 | 137 | 152 | 160 | 5.1 |
| West Germany ^{b/} | 92 | 103 | 110 | 115 | 121 | 140 | 149 | 4.5 |
| Italy | 92 | 109 | 120 | 126 | 133 | 152 | 161 | 5.2 |
| Japan | 92 | 105 | 115 | 125 | 135 | 151 | 158 | 5.0 |
| Canada | 88 | 102 | 107 | 118 | 126 | 136 | 142 | 4.4 |
| 2. Consumer Price Index (All Goods): | | | | | | | | |
| United States | 97 | 101 | 105 | 111 | 121 | 134 | 138 | 3.3 |
| United Kingdom | 93 | 102 | 110 | 118 | 130 | 151 | 161 | 5.1 |
| France | 92 | 105 | 112 | 118 | 130 | 145 | 154 | 4.8 |
| West Germany | 95 | 103 | 110 | 115 | 120 | 130 | 138 | 3.5 |
| Italy | 93 | 107 | 118 | 125 | 131 | 144 | 151 | 4.5 |
| Japan | 88 | 108 | 119 | 130 | 144 | 165 | 172 | 6.3 |
| Canada | 97 | 102 | 106 | 114 | 124 | 131 | 138 | 3.3 |

TABLE 6. COMPARATIVE RATES OF INFLATION:^{a/}
U.S. VERSUS SELECTED EUROPEAN COUNTRIES, JAPAN AND CANADA, 1960-1972--Continued

| Indicator and Country | 1962 = 100 | | | | | | | Average Annual Rate of Change In 1960-1972, Percent |
|---|------------|------|------|------|------|------|-------|---|
| | 1960 | 1963 | 1965 | 1967 | 1969 | 1971 | 1972p | |
| 3. <u>Index of Wholesale Prices of Finished Manufactured Goods:</u> | | | | | | | | |
| United States | 100 | 100 | 102 | 106 | 113 | 121 | 125 | 2.0 |
| United Kingdom | 95 | 101 | 108 | 112 | 121 | 139 | 147 | 4.0 |
| France | 96 | 103 | 106 | 108 | 117 | 130 | 136 | 3.2 |
| West Germany ^{e/} | 94 | 101 | 105 | 108 | 105 | 120 | 125 | 2.6 |
| Italy ^{c/} | 97 | 105 | 111 | 112 | 116 | 128 | 131 | 2.8 |
| Japan ^{d/} | 100 | 101 | 103 | 105 | 110 | 114 | 116 | 1.4 |
| Canada | 97 | 102 | 105 | 110 | 118 | 124 | 132 | 2.8 |

p Preliminary

a/ Price indexes of export goods are not considered because of their lacking or unknown meaning.

b/ Gross domestic product.

c/ Index of average (general) wholesale prices.

d/ Weighted average of the wholesale price indexes for consumer and producers' goods.

e/ Weighted average of the wholesale price indexes for consumer and investment goods.

Sources:

OECD, National Accounts of the OECD Countries, 1960-1970; OECD, Main Economic Indicators, 1959-1969;
Ibid, February 1973; OECD, Economic Outlook, No. 12, December 1972; OECD, Economic Surveys, Selected Countries,
Selected Years; and National Institute Economic Review, No. 63, February 1973.

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of affairs--by as much as \$2.5 to \$3.5 billion, depending on the year and what is counted as a "noncommercial" transaction.¹⁸

Bearing these three points in mind, we may proceed with the analysis.

In trade in agricultural products the United States ran deficits early and well into the 1950's, but during the 1960's it consistently scored gross surpluses, ranging between \$1.1 and \$2.1 billion, and the long-term tendency of these surpluses has been upward because of the slightly faster growth of exports than imports. Most, but a decreasing amount, of these surpluses, however, have been derived from "noncommercial" exports, largely sales for nonconvertible currencies, outright donations and long-term dollar credits under Public Law 480. The trade balances in agricultural products of the truly commercial nature have been either small surpluses or small deficits. The large increase in U.S. exports in 1972, and the resultant large surplus, is attributable to extraordinary purchases by the USSR and stockpiling by some other countries.

In trade with minerals, fuels and other nonagricultural raw materials, the United States had deficits in most years between 1910 and 1920 and in every year since 1921. In the time span covered

¹⁸See Michael Boretsky, "Concerns About the Present American Position in International Trade" in National Academy of Engineering, Technology and International Trade, 1970, pp. 26-27; and U.S. Department of Commerce, Overseas Business Reports, OBR 73-12, May 1973, p. 5.

in Tables 4 and 5, the annual deficit grew from about \$2.0 billion in 1951-1955 to \$4.1 billion in 1971. In 1972 the deficit amounted to about \$4.5 billion. The growth of this deficit has been almost proportionate to the real growth of GNP and it is clearly attributable to the inadequacy of natural resources, especially oil, in the United States relative to the economy's needs.¹⁹

In trade with not technology-intensive manufactured products, the United States was a net exporter (had a surplus) in 1951-1955 and until 1959. In that year it became a net importer, by 1971 the annual deficit reached \$8.3 billion, and in 1972 this deficit was close to \$12 billion.

U.S. trade in technology-intensive manufactured products is the most voluminous and this commodity group is the only one that has

¹⁹The dependence on imports of raw materials is common to all western industrial countries except Canada, it is rapidly increasing, and all are substantially more dependent than the United States. I estimate that in 1970 France's relative dependence on imports of extractive raw materials and fuels was 4.2 times as great as that of the United States; West Germany's--about 4.6 times as great; Italy's--about 5 times as great; and United Kingdom's--about 5.5 times as great. The disparity between the dependence of these foreign countries and the United States on all raw materials, including agricultural raw materials and industrial "wastes" and scrap, is even more substantial. In the years ahead, therefore, we must expect a tremendous world-wide scramble for minerals and other raw materials on the part of all industrialized countries, except, perhaps, Canada and the USSR, and a tremendous intensification of competition for export markets of manufactured goods to secure "hard" currency in order to pay for the imports of raw materials.

consistently yielded surpluses that have covered deficits in trade with other commodity groups as well as deficits arising from other U.S. financial transactions with foreign countries. The gross surplus yielded by trade in this commodity group averaged \$5.7 billion in 1951-1955, \$7.7 billion in 1962, and reached \$9.1 in 1965. From 1965 until 1970 it fluctuated between \$9.1 and \$9.4 billion. In 1971, however, the surplus slipped to \$8.2 billion and in 1972 to about \$6.6 billion.

U.S. total merchandise trade is largely the result of the trade in the four groups. In the aggregate the deterioration in U.S. trade position could hardly have been more dramatic--almost a 180 degree turnaround of the overall balance in just seven years, from a \$6.1 billion surplus in 1965 to a deficit of about \$5.9 billion in 1972.

Part of this turnaround is attributable to a doubling of the deficit in trade in minerals, fuels and other raw materials--from \$2.8 billion in 1965 to \$4.5 billion in 1972, where the principal force at work has been clearly the insufficiency of natural resources in the United States relative to the economy's needs. The bulk of it, however, occurred in trade with manufactured goods, both not technology-intensive and technology-intensive, where the overall U.S. surplus turned from a surplus of \$6.1 billion 1965 to a deficit of \$5.1 billion, a deterioration amounting to more than \$11 billion.

Contrary to general beliefs, the comparison of growth rates of U.S. imports and exports shown in Table 5 indicates that this

deterioration has not occurred suddenly but has been in the making since the early 1950's. In trade with not technology-intensive manufactured products, the ratio of the growth of U.S. imports to exports was 10.4 to (-) 0.6 in 1951 to 1955 to 1962, about 1.8 to 1 in 1962-1971, and 21.9 to (-) 3.2 in 1972 over 1971; and in trade with technology-intensive products this ratio was about 2.5 to 1 in 1951-1955 to 1962, 2.2 to 1 in 1962-1971, and 2.6 to 1 in 1972 over 1971.

This long-term deterioration was taking place despite much lower rates of inflation, as it is usually defined, throughout the period in the United States than in other industrialized countries. Within the framework of my theory, this could have happened only because the levels of foreign prices had been lower than U.S. prices (in order to be so they must have been lower prior to the period covered in the analysis and the countries' faster rates of inflation in the period were not sufficiently large to offset this advantage) and/or because the industrial and technological capabilities abroad have grown faster than in the United States.

Regarding the relative price levels I previously referred to the National Bureau of Economic Research (NBER) study which showed that in the area of nonelectrical machinery, and, one might presume, in most kinds of capital goods, the prices of comparable products abroad were indeed substantially lower than in the United States.²⁰ Table 7

²⁰See p. 23 above.

TABLE 7. COMPARATIVE LEVELS OF DOLLAR PRICES OF CLOTHING BASED ON JAPAN
NATIONAL LIFE INSTITUTE'S ESTIMATES FOR 1960 AND INDIVIDUAL COUNTRIES'
DATA ON THE RESPECTIVE CONSUMER PRICE CHANGES IN 1960-1970

| U.S. = 100 | | | | |
|--|------|------|------------------|---|
| Country | 1960 | 1965 | 1970 | Relative Aggregate Change from 1960 to 1970, Percentage Points |
| United States | 100 | 100 | 100 | — |
| France | 67 | 75 | 70 | + 3 |
| West Germany | 69 | 76 | 65 | - 4 |
| Belgium | 74 | 81 | 74 | 0 |
| Netherlands | 62 | 69 | 69 ^{a/} | + 5 |
| Italy | 65 | 78 | 72 | + 7 |
| Sweden | 68 | 75 | 66 | - 2 |
| Simple Average for the Six European Countries | 68 | 76 | 69 | + 1 |
| Japan | 45 | 54 | 55 | +10 |

a/ 1969

Sources:

1960 - Office of the Prime Minister, Bureau of Statistics, Kokumiu Seikatsu Habusko (National Life White Paper, in Japanese), Tokyo, 1965, Section I-2, Table 2 (Translation of selected parts provided by the Department of State's Language Service). The source provides no detail as to the composition of the observations used in the comparison or the methodology except that the comparisons employed geometrically averaged U.S. and Japanese quantity weights. It seems quite safe to assume that the methodology was analogous to that used by Milton Gilbert and Irving Kravis in their comparisons of the purchasing power of the dollar and selected European currencies in the 1950's.

1965-1970 - Extrapolation from 1960 in accordance with the respective countries' implicit consumer price indexes for clothing as reported in OECD, National Accounts of OECD Countries, 1960-1970.

indicates that they have been much lower in some consumer goods areas, and Table 8 implies that as of 1970 this must have been true in practically all areas of manufactured goods and in practically all foreign countries.²¹

Needless to say, all of this statistical information provides merely approximate quantitative dimensions to the substantive knowledge of the many millions of U.S. residents who travelled abroad in the 1950's and 1960's: in most places, if not all, their dollar bought a lot more goods and services abroad than in the United States.

Because rates of inflation abroad are known to have been higher than in the United States, it would not be sensible to presume that the foreign countries' trade advantage in the form of lower prices was increasing. Therefore, the lower levels of foreign prices cannot be termed as the primary factor behind the deterioration in U.S. trade (underway, as shown in Table 5, since the early 1950's). From this it follows that the primary force behind this deterioration has been

²¹ The estimates in Table 8 formally refer only to the experience of U.S. companies, largely the best or most progressive companies in the United States, and only in regard to their costs rather than relative prices. There is good reason to assume (see, e.g., The Oriental Economist, February 1969, p. 22), however, that the experience of these U.S. companies abroad are not grossly dissimilar from the experiences of the best foreign companies operating in the respective countries and these are, of course, the companies we largely have in mind when we talk about the "international competitiveness" of U.S. industry. Moreover, the inclusion of the cost items that would bring these estimates to the level of comparative prices (profits and taxes) would not change the relatives appreciably, especially if the focus is on the relative prices relevant for international trade (net of indirect taxes).

TABLE 8. APPARENT OR PROBABLE COMPARATIVE LEVELS OF PRODUCTIVITY AND COMPARABLE DOLLAR COST, BY MAJOR TYPE, OF 298 U.S.-BASED MULTINATIONAL MANUFACTURING COMPANIES IN THEIR U.S. AND OVERSEAS FACILITIES, 1970 AND 1973

| Item | LOCATION OF FACILITIES | | | | | | | Developing Countries |
|--|------------------------|-------------------------------------|-----------------------------------|--------|---|----------------|--------|----------------------|
| | U.S. | All Foreign Countries ^{a/} | Developed Countries ^{b/} | Canada | European Economic Community ^{c/} | United Kingdom | Japan | |
| 1970: | | | | | | | | |
| 1. Annual Cost per Employee (Wage and Fringe Benefits), \$ | 13,124 | 4,819 | 5,290 | 8,461 | 5,320 | 3,944 | 4,162 | 2,807 |
| 1a. Ditto, Percent of the U.S. | 100 | 37 | 40 | 64 | 40 | 30 | 32 | 21 |
| 2. Annual Sales, includes Multiple Counting, per Employee, \$ | 37,270 | 24,231 | 25,953 | 40,878 | 24,728 | 19,592 | 30,054 | 16,878 |
| 2a. Ditto, Percent of the U.S. | 100 | 65 | 69 | 109 | 66 | 52 | 80 | 45 |
| 3. Apparent Physical Output per Employee Relative to the U.S. | 100 | 78 | 83 | 86 | 82 | 63 | 102 | 62 |
| 4. Apparent Dollar Cost per Unit of Physical Output Relative to the U.S. | | | | | | | | |
| a. Cost of Labor | 100 | 48 | 53 | 74 | 49 | 48 | 31 | 34 |
| b. Cost of Capital Net of Profits (Depreciation and Interest) | 100 | 96 | 101 | 100 | 96 | 78 | 131 | 82 |
| c. Cost of Materials, Energy and Services Except Indirect Taxes | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| d. Cost of Labor, Capital, Materials, etc. (Sum of Items a through c) | 100 | 74 | 77 | 90 | 73 | 71 | 66 | 65 |

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TABLE 8. APPARENT OR PROBABLE COMPARATIVE LEVELS OF PRODUCTIVITY AND COMPARABLE DOLLAR COST, BY MAJOR TYPE, OF 298 U.S.-BASED MULTINATIONAL MANUFACTURING COMPANIES IN THEIR U.S. AND OVERSEAS FACILITIES, 1970 AND 1973--Continued

| Item | LOCATION OF FACILITIES | | | | | | | |
|--|------------------------|-------------------------------------|-----------------------------------|--------|---|----------------|-------|----------------------|
| | U.S. | All Foreign Countries ^{a/} | Developed Countries ^{b/} | Canada | European Economic Community ^{c/} | United Kingdom | Japan | Developing Countries |
| 1973: | | | | | | | | |
| 5. Probable Annual Rate of the Dollar Cost per Employee in the Middle of the Year, \$ | 15,880 | 7,920 | 9,477 | 10,902 | 10,066 | 5,565 | 9,120 | 3,246 |
| 5a. Ditto, Percent of the U.S. | 100 | 50 | 60 | 69 | 63 | 35 | 57 | 20 |
| 6. Probable Physical Output per Employee Relative to the U.S. | 100 | 83 | 90 | 88 | 82 | 64 | 115 | 60 |
| 7. Probable Dollar Cost per Unit of Physical Output as of the Middle of the Year Relative to the U.S. | | | | | | | | |
| a. Cost of Labor | 100 | 60 | 67 | 78 | 77 | 55 | 50 | 34 |
| b. Cost of Capital Net of Profits (Depreciation and Interest) | 100 | 93 | 100 | 105 | 99 | 67 | 122 | 70 |
| c. Cost of Materials, Energy and Services Except Direct Taxes | 100 | 108 | 109 | 103 | 117 | 105 | 109 | 103 |
| d. Cost of Labor, Capital, Materials, etc. (Sum of Items a through c) | 100 | 80 | 87 | 90 | 95 | 76 | 81 | 65 |
| 8. Change in Relative Total Dollar Cost Abroad Vis-a-Vis the U.S. in 1973 Over 1970 (Item 7d over 4d), Percent | — | + 8 | + 13 | 0 | + 30 | + 7 | + 23 | 0 |

a/ Items 3 through 7 represent U.S.-import-weighted averages for all developed and developing regions rather than the companies' sales-weighted averages.

b/ Items 3 through 7 represent U.S.-import-weighted averages for all developed countries, including "Rest of Europe," and Australia, New Zealand and South Africa which are not shown in the table.

c/ Six original member countries.

Sources: See APPENDIX

the faster growth of industrial and technological capabilities abroad than in the United States. By the term "growth of the capabilities" I, of course, mean the relative growth of the quality of the know-how as well as its scope and the availability of appropriate plant and equipment in which this know-how is translated into the production of goods and services.

Please, note that in making this statement I refer to relative rates of growth of the capabilities in question and not to their level. There is no evidence yet that the level of technological capabilities (know-how) in foreign countries has surpassed the level of U.S. capability in any important product line, but there is no question whatever that the differences between the United States and foreign levels that existed in the past (the "gap") have narrowed, and in many product lines they have disappeared altogether, and that this narrowing of the gap is the cause of the deterioration in U.S. trade. The fact of the narrowing of the "gap" can be readily demonstrated by a number of direct indicators and it is fully consistent with the slower growth in productivity in the United States than abroad which I analyzed in the preceding section. It is also fully consistent with the U.S. gap in R & D effort for purposes of economic development, a rapid and practically one-way exportation of advanced U.S. manufacturing technology, and some other indicators which I shall discuss in a moment.

By August 1971 this long-term deterioration had forced an unprecedented in economic history (because of lower rates of inflation

in the United States than abroad) devaluation of the dollar, nominally by 12 percent and actually (U.S.-imports weighted average) by about 6 percent, followed in February of 1973 (14 or 17 months later, depending how you count it) by another formal devaluation of nominally 10 percent, and actually by about 5 percent (import-weighted average). From this second devaluation (February 1973) until the end of June 1973, the dollar's "floating" yielded the third devaluation amounting to 5 percent or so, that is, almost as big as each of the preceding two. In the aggregate, the world-wide (U.S.-imports-weighted) devaluation of the dollar from December 1971 until the middle of 1973 amounted to about 16 percent with the following breakdown by major countries and regions:²²

| Foreign Currency | Change of Dollar's Value Via-a-vis Foreign Currencies From December 1971 to June 29, 1973, Percent |
|--|---|
| Canadian dollar | - 1.0 |
| Currencies of EEC | - 27.5 |
| --French Franc | - 25.6 |
| --West German Mark | - 33.9 |
| Swiss Franc | - 33.5 |
| British pound | - 7.1 |
| Currencies of all developed western countries | - 17.4 |
| Currencies of LDC's | - 2.7 |

²²Data compiled by Commerce's Bureau of International Commerce, International Trade Analysis Staff.

As I read the developments in U.S. trade from the middle of August 1971 to January 1973 the primary effect of the first devaluation was a further deterioration in the trade balance, largely because of a worsening in the U.S. terms of trade, just about by the amount of the actual world-wide devaluation.²³ The effects of the

²³Regarding this assessment I should note in at least an extended footnote the fact that there are many economists, especially in the Washington area, who argue that the deterioration in the U.S. trade balance in 1972 over 1971 was caused largely by the initial "perverse" effects of the dollar devaluation in December 1971 and that the improvement would have come once these "perverse" effects were over. A good number of these economists also seem to believe that by now, after the February and the "floating" devaluations in March - June 1973, the dollar is grossly undervalued and that we will soon witness a reversal of the devaluations.

As I understand it, the analysis leading to this position is predicated on a host of assumptions the most important of which would seem to be: (a) There are many internationally-traded commodity areas where U.S. industry's weak price competitiveness is marginal; (b) Devaluation of the dollar would exert proportional effect on dollar cost and the price of commodities abroad; (c) The elasticities of foreign demand for U.S. exports with respect to price are high and, hence, even a small change in exchange rates is likely to produce substantial results; and (d) Any devaluation, however small, always produces favorable results, witness the French and the British experiences in respectively, late 1950's and 1960's, although, as in the British experience, there might be considerable delay in the positive results.

As far as I am concerned, all of these assumptions are extremely "heroic." Regarding (a), while there might be some commodity areas in which U.S. industry's weak price competitiveness might have been only marginal, at least as of 1970-1971 the overall gap was apparently so large (see Tables 7 and 8) that it is virtually impossible that there could be many such instances. Regarding (b), devaluation of the dollar would produce fully proportional effect on dollar prices abroad only if the economic dynamics were the same abroad as in the United States and there were no other interferences regarding the pricing of internationally traded goods. As is implied

second and third devaluations might and perhaps will be better,

Footnote 23 Continued

in Table 8, Item 8, the differences in economic dynamics alone are likely to offset more than half the impact of the December 1971 - June 1973 devaluation on the total cost of U.S. companies in all foreign countries (appreciation of all foreign currencies by 16.4 percent, but the relative cost increase by only 8.1 percent), the companies' relative total cost in EEC facilities by some 20 percent (appreciation of the EEC currencies by 38 percent, but the companies' relative cost increase by 30 percent), the companies' relative cost in Japan by about 40 percent, etc. In addition, foreign companies dependent on exports might choose to mitigate the impact of the devaluation on the export prices of their products by absorbing part of the would-be increase in reduced profits (especially in instances where the long-term dynamics promises to be offset in the future). Regarding (c), the only estimates that yield high foreign demand elasticities for U.S. products with respect to price (as well as extremely high domestic demand-price elasticities for imports) are those based on export and import unit values (such as, e.g., produced by Stephen P. Magee for the Council of Economic Advisers in his A Theoretical and Empirical Examination of Supply and Demand Relationships in U.S. International Trade, October 1970-mimeo), but, as I noted earlier, BLS has found these measures totally meaningless as proxies for prices. To my knowledge, attempts to estimate these elasticities on the basis of relative changes in wholesale prices of manufactured goods produce incomparably smaller values (compared with Magee's estimates). Moreover, there is also the question of how useful is the concept itself for such important trade transactions as U.S. imports of oil and other raw materials, on one hand, and the export of U.S. grain to the USSR, on the other. Regarding (d), finally, Joan Robinson demonstrated long ago (see her "The Foreign Exchanges," Essays in the Theory of Employment, New York, 1937, pp. 188-201) that devaluation is not the panacea for all trade difficulties. The outcome of any devaluation depends on all relevant elasticities and other factors outside the scope of the analysis of elasticities and there are at least theoretically-defined situations where the upward revaluation rather than devaluation might be the prudent course of action. The fact that devaluations seemingly worked in France and Britain is not necessarily instructive for the United States. Indeed, my analysis leads me to believe that the modest and delayed improvement in the British trade balance following their devaluation of the pound in 1967 was probably caused largely by the prolonged suppression of domestic demand by the Government's deflationary policies, including a substantial increase in the unemployment rate, and a large influx of export-expanding foreign direct investment, chiefly from the United States, rather than the devaluation.

but at the time of this writing no clear-cut evidence to this effect can be discerned from either the trade or any other data.

In fact, as of the middle of 1973 the U.S. trade situation might best be described to have been in a state of aggravated disequilibrium even though the overall trade deficit seems to be shrinking. The relevant data are given in Tables 9 and 10.

On the export side, the most disequilibrating factor is the foreign demand for U.S. agricultural products and raw materials. In the first six months of 1973 U.S. exports of agricultural products in current prices were 82 percent larger than in a comparable period of

Footnote 23 continued

My assessment of the effect of the December 1971 devaluation stated in the text is, of course, consistent with the large differences in the average price levels in the United States vis-a-vis foreign countries implicit in Tables 7 and 8, and it implies that what that devaluation (world-wide average of 6 percent) did to U.S. trade in 1972 was to make U.S. imports smaller bargains than in 1971 or before, but still left most of them, if not all, substantial bargains; and, on the export side, it made most U.S. products somewhat cheaper than in 1971 and before that year, but left them still far from competitive on world markets if they were to sell on the basis of price alone. The continued trend of the narrowing technological gap obviously worked in the same direction. Inasmuch as consumers, both in the United States and abroad, "go for bargains" rather than marginal changes therein, the "perverse" effects were hardly perverse. Indeed, as far as I am concerned, they reflect as rational behavior of the market place (consumers) as economic theory wants them to be (and postulates). Parenthetically I might also add that in the analysis involving as big cost and price differences and as rapid shifts in technological and industrial capabilities as we are concerned with here the use of the elasticity concept would not seem to be very helpful.

TABLE 9. GROWTH IN U.S. MERCHANDISE EXPORTS AND IMPORTS IN THE FIRST HALF OF 1973
 COMPARED WITH 1972 AND THE 1962-1971 PERIOD, PERCENT PER YEAR (CURRENT PRICES)

| Commodity Group | 1962-1971 | 1971-1972 | January-June 1973 Over January-June 1972 (Preliminary) |
|---|-----------|-----------|---|
| <u>Agricultural Products</u> | | | |
| Exports | 4.0 | 22.1 | 82.0 |
| Imports | 3.7 | 12.1 | 26.8 |
| <u>Minerals, Fuels & Other Raw Materials</u> | | | |
| Exports | 5.5 | 36.8 | 36.3 |
| Imports | 5.2 | 22.8 | 34.8 |
| <u>Not Technology-Intensive Manufactured Products</u> | | | |
| Exports | 5.5 | -3.2 | 29.2 |
| Imports | 10.0 | 21.9 | 18.7 |
| <u>Technology-Intensive Manufactured Products</u> | | | |
| Exports | 8.2 | 9.7 | 26.7 |
| Imports | 18.3 | 25.4 | 21.0 |
| <u>All Commodities</u> | | | |
| Exports | 6.7 | 12.7 | 37.3 |
| Imports | 9.7 | 21.9 | 23.0 |

Sources:

Table 1 and U.S. Department of Commerce, Bureau of the Census, Highlights of U.S. Exports and Import Trade, FT-990, June 1973.

TABLE 10. SELECTED STATISTICS BEARING ON AGGREGATE SUPPLY, DEMAND AND WHOLESALE PRICES OF AGRICULTURAL PRODUCTS IN THE U.S.: 1973 COMPARED WITH 1965 AND 1970-1972

- 55 -

| Item | 1965 | 1970 | 1971 | 1972 | 1973 |
|---|-------|-------|-------|-------|---------------------|
| I. Key Values In Current Prices and Wholesale Price Indexes: | | | | | |
| 1. Total value of marketed domestic farm products (equals the cash receipts of farmers from marketings), \$ billion | 39.3 | 50.5 | 53.1 | 58.0 | 80.9 |
| 2. Exports of farm products, \$ billion | 6.2 | 7.2 | 7.7 | 9.4 | 17.1 ^{a/} |
| 3. Addition to (+) or subtraction from (-) inventories, including stockpiles, \$ billion | +0.5 | -1.4 | +1.1 | -0.6 | ... |
| 4. Imports of agricultural products, \$ billion | 4.1 | 5.8 | 5.8 | 6.5 | 8.2 ^{a/} |
| 5. Apparent supply to domestic market, ^{b/} \$ billion | 36.7 | 50.5 | 50.1 | 55.7 | 72.0 |
| 5a. Ditto, per capita of population, \$ | 188.9 | 246.5 | 242.0 | 266.7 | 342.0 |
| 6. Wholesale price index of farm products, 1967 = 100 | 98.7 | 111.0 | 112.9 | 125.0 | 167.5 ^{a/} |
| II. Key Values in 1967 Prices: | | | | | |
| 7. Total value of marketed domestic farm products, \$ billion | 39.8 | 45.5 | 47.0 | 46.4 | 48.3 |
| 8. Exports of farm products, \$ billion | 6.3 | 6.5 | 6.8 | 7.5 | 10.2 |
| 9. Addition to (+) or subtraction from (-) inventories, including stockpiles, \$ billion | +0.6 | -1.3 | +1.0 | -0.5 | ... |
| 10. Apparent supply to domestic market ^{b/} \$ billion | 37.1 | 45.6 | 44.2 | 44.7 | 43.0 |
| 10a. Ditto, per capita of population, \$ | 190.9 | 222.6 | 213.5 | 214.0 | 204.2 |
| 10b. Apparent trend in per capita domestic demand, ^{c/} \$ | 190.9 | 210.0 | 213.5 | 217.6 | 221.7 |
| III. Selected Ratios: | | | | | |
| 11. Real growth of domestic output of market products from preceding year, percent | 1.3 | 3.2 | 3.3 | -1.3 | 4.0 |
| 12. Exports as a percent of the total value of marketed domestic products | 12.3 | 14.3 | 14.5 | 16.2 | 21.1 |
| 12a. Growth in exports in current prices from preceding year, percent | -1.9 | 22.1 | 6.2 | 22.1 | 82.0 |
| 12b. Real growth of exports from preceding year, percent | -1.6 | 20.4 | 4.6 | 10.3 | 36.0 |
| 13. Real growth of apparent supply to domestic market ^{b/} from preceding year, percent | +2.2 | +2.1 | +2.5 | -2.6 | -2.5 |
| 13a. Ditto, per capita of population | +0.9 | +1.0 | +1.4 | -3.5 | -3.3 |
| 14. Ratio of apparent per capita supply to domestic market in 1967 prices (Item 10a) to apparent per capita demand implicit in the 1965-1971 trend (Item 10b) ^{d/} | 1.00 | 1.06 | 1.00 | 0.98 | 0.92 |
| 15. Growth in wholesale price index from preceding year, percent | +4.3 | +1.7 | +1.7 | +10.7 | +34.0 ^{a/} |

TABLE 10. SELECTED STATISTICS BEARING ON AGGREGATE SUPPLY, DEMAND AND WHOLESALE PRICES OF AGRICULTURAL PRODUCTS IN THE U.S.: 1973 COMPARED WITH 1965 AND 1970-1972--Cont.

... Connotes nil (either addition or subtraction)

- a/ Estimated by applying the ratio of January-June 1973 over January-June 1972 to the respective value or index for 1972.
- b/ Total value of marketed domestic products plus imports minus exports, plus subtraction from or minus addition to the stockpiles. In estimating this series in 1967 prices (Items 9 and 9a) it is assumed that the prices of imports changed the same way as domestic prices which is not necessarily true. The resulting errors in the respective totals, if any, however, cannot be too great since imports in current prices represented only 11 to 12 percent of the total supply.
- c/ Least square line fitted to the 1965-1971 data, yielding growth rate of 1.9 percent per year.
- d/ This figure (1.00 minus the posted ratio) indicates a probable deficiency of supply to domestic market in terms of a percent of the demand.

Sources of the Data in Section I.

Item 1. For 1965-1972, U.S. Department of Agriculture, as reported in the Economic Report of the President, 1973, Table C-81, p. 287. The estimate for 1973, \$80.9 Billion, is based on the Department's projection of the real growth of total agricultural output in 1973 over 1972 (4 percent) plus price increases of 34 percent (Item 5).

Item 2 and 4. U.S. Department of Commerce, Bureau of the Census (consistent with Tables 5, 6 and 9).

Item 3. U.S. Department of Agriculture, Economic Research Service.

Item 4 and 4a. See note (b) above. The 1973 per capita supply assumes U.S. population in 1973 to be about 210.5 million (the figure supplied by the Bureau of the Census).

Item 5. U.S. Department of Labor, Bureau of Labor Statistics.

1972 (Table 9), and about 36 percent larger in 1972 prices (Table 10), compared with an average annual growth (in current prices) of only 4 percent per year in the 1962-1971 period, the nine years prior to the first devaluation. Calculated on an annual basis, this acceleration has pushed the volume of exports of the products in question to a level about 21 percent of the entire value of domestic output of agricultural products (compared with about 12 percent in 1965 and 14 percent or so in 1970 and 1971)--the magnitude well above the sector's ability to sustain it without causing serious shortages in the supply to domestic markets and thus creating virtually uncontrollable inflationary pressures in the economy at large (see Table 10, Section III).²⁴ In response to these inflationary pressures, restrictions were temporarily imposed on certain commodities. The effects of these restrictions will be seen only in the second half of the year. All of this, of course, is rather disappointing because it indicates that the U.S. agricultural sector does not have as great potentialities for the expansion of exports and, thus, making up for losses in the industry's

²⁴Much of the demand for these products (as well as raw materials) comes from continental Europe and Japan, that is, the countries which revalued their currencies vis-a-vis the dollar by the greatest margins. In contrast to the United States, along with imports of the products in question they import deflation to the extent to which their percentage revaluations exceed the price increases of the products in the United States.

technological advantage as many had hoped.²⁵ A similar situation prevails in the area of nonagricultural raw materials. The January-June

²⁵The key determinants of farm output, both the final-demand of grain foods and of livestock yielding meat, dairy products and poultry requiring grains for feeding, are acreage of planted or otherwise cultivated cropland and the yield per cultivated acre due to weather conditions and technology, largely the use of fertilizer and insecticides. In the 1960's and in the 1970-1972 period, according to the Department of Agriculture's Soil Conservation Service, 59 to 62 million acres of useable cropland were kept idle in "Government Set-Aside Programs" and an additional 50 to 100 million acres lie idle due either to poor quality or the size of parcels too small for economical farming. In 1973 USDA estimates that about 70 percent (43 million acres) of the readily usable idle acreage was brought under cultivation and the reserve of such land was thus reduced to about 19 million acres, or a mere 6 percent of the harvested cropland in 1973. Historically, at least since 1950, the yield per acre has grown on the average by about 2.2 percent per year while the use of fertilizer and liming materials by about 6.5 percent per year (see Economic Report of the President, 1973, Tables C-83 and C-85, p. 289). Given the strong market demand that currently prevails, and average weather conditions, we might, therefore, expect that farm output in 1974 might increase in real terms by a maximum of some 8 percent or so over 1973 (because of maximum additional acreage of about 6 percent and an increase in the yield per acre by about 2 percent or so). The 8 percent growth of farm output in 1974 would just about suffice for elimination of the 1973-type of shortages in the supply of domestic market, including the provision for the growth of population, but allow little, if any growth of exports without continued rise in prices unless, of course, there were a substantial increase in imports of the products in question. After 1974, however, the growth of the farm output is likely to be largely a function of the growth in the yield per acre, a maximum of some 2 to 2.5 percent per year, just about as big as the growth of domestic demand, that is, per capita plus growth of population unless the U.S. farm sector rapidly shifts to the kind of intensive technology that is presently being used in the Netherlands and Denmark. Such a shift, however, requires a massive redirection of labor and capital back to agricultural sector and this could not be accomplished "overnight" and in the long run, without a drastic change in the relative income levels of farm labor and relative return on investment in agriculture compared with alternative employment and/or investment in sectors other than agriculture. This intensification of farming would also have drastic implications for water pollution in many regions of the country.

1973 exports of these products were about 36 percent larger than a year ago in current prices and about 25 percent larger in 1972 prices, compared to an average annual growth in current prices, of only 5.5 percent per year in the 1962-1971 period. This acceleration, too, has pushed the volume of exports of the products in question beyond the country's ability to sustain and here, too, export controls on key products (lumber, metal scrap) have been imposed.

The January-June 1973 growth in exports of manufactured products, both technology-intensive and not technology-intensive (Table 9) is, of course, not disequilibrating the economy and it is generally of the magnitude which, if sustained over some time to come, would markedly improve the U.S. trade position (and make the devaluation pay off), but it seems highly improbable that this growth would continue for too long. Regarding this, one has to bear in mind that the current growth of these exports, as well as that of agricultural products and raw materials, is being helped not only by the devaluation of the dollar but also by an appreciably faster than usual economic growth abroad,²⁶ induced largely by recovery from recessions in

²⁶At the middle of the year OECD projected that in the whole year of 1973 real economic growth in the EEC countries will average about 6 percent, compared with an annual average of about 5 percent in the 1960-1971 period; in the United Kingdom, about 6.3 percent compared with an average of 2.7 percent per year in the 1960-1971 period; in Canada, 7.3 percent compared with 5.1 percent per year in the 1960-1971 period; and in Japan, 13.5 percent compared with an average of 10.6 percent per year in the 1960-1971 period. See OECD, Economic Outlook, No. 13, July 1973, pp. 13-14.

the 1971-1972 period and which is not likely to last; increased inflationary pressures all over the world²⁷ which, if continued, might easily lead to a world-wide depression; apparent attempts of Japan and West Germany to deliberately reduce their trade surpluses with the United States, thereby reducing pressures for further revaluations of their currencies, by importing more from the United States than market forces alone would produce, and this not only of commodities which they usually import from the United States (grains, raw materials and technology-intensive capital equipment), but also commodities which they traditionally exported to the United States in large volumes but hardly imported²⁸--a phenomenon which is not likely to last long; and,

²⁷According to OECD again, in 1973, e.g., West Germany's GNP deflator will rise by about 6.8 percent, compared with an average annual increase of 4.5 percent in the 1960-1972 period; in France, by 6.3 percent compared with average of 5.1 percent in the 1960-1972 period; in the United Kingdom, by 6.5 percent compared with an average of 4.8 percent in 1960-1972 period; in Japan, by 7.5 percent compared with 5.0 percent in 1960-1972; and in Canada, by 5.5 percent, compared with an average of 4.4 percent in the 1960-1972 period. See ibid., p. 25.

²⁸In the June 1973 issue of the journal Exchange, p. 3, the situation in traditionally depressed textile industry, e.g., is described in the following terms:

"During the Sixties exports managed to increase to \$776 million from \$600 million at the beginning of the decade; last year they were just short of a billion dollars. One big reason for the spurt has been enormous purchases by the Japanese. Says one trade source: They are buying everything--fiber and fabric. Every textiles sales office here has been approached by Japanese buyers who are offering premium prices. There are just not enough goods to go around he notes."

finally, by U.S. trade initiatives with the USSR and China, the outcome of which (apart from grain) will heavily depend on the availability of long-term credits in the United States and the USSR's rate and volume of progress in producing the kind of exportable products which could be competitively sold in U.S. markets.

The import side would not seem to be conducive to much optimism either. Despite the three devaluations, the rate of growth of imports in all product groups continues to be much higher than it was before the first devaluation (1962-1971) and whatever signs of deceleration might be discerned in the data for January-June of 1973 compared with 1972, their implications are trifling. Moreover, we know that U.S. imports of raw materials and manufactured goods are likely to continue to grow rapidly, and the former, because of oil, might even appreciably accelerate because, in the case of raw materials, of the growing deficiency in domestic supply, and in the case of manufactured goods, if only because, as was shown in Table 8, manufacturing costs in practically all foreign countries remain lower than in the United States despite the three devaluations. On top of this, as shall be shown somewhat later, the rate of growth in technological and industrial capabilities is likely to continue to be faster in most other industrialized countries for some time to come whether the United States initiates policies that would counter this trend or not (because of the time-lag these policies would require to produce any effects).

Other Problems

There are a number of other serious problems with implications for technology, but their nature is generally much more obvious and/or better understood than the preceding two. Therefore, I shall dwell on them only as much as is necessary to bring them into focus of this analysis:

-- Though we have known about the oncoming energy crisis and the most rational technological routes of averting it for more than a decade, virtually nothing was done to avert the crisis until it arrived. When the crisis finally arrived we try to cope with it by a huge increase in imports (about 30 percent in 1972 over 1971 compared with average annual growth of 7.5 percent in 1962-1971) at a tremendous cost to society because of the additional strain on the balance of payments and the rationing of energy through soaring prices.

-- Even though we have much more land area per head of population than any European country, the quality of American air and water are by now as bad as in the industrialized parts of Europe. In most cases the technological solutions to the pollution problems are at hand, but the projected cost of the crash pollution control programs which we are embarking on is staggering, and clearly indicating that the available pollution control technology is far from optimum.

-- Many of the largest American cities, and countless smaller ones, are practically decaying. In some of the largest, existing housing units are reportedly being abandoned at rates faster than

the construction of new units. Though causes of this phenomenon are undoubtedly numerous, one of the most important, if not the most important, among them is the mounting cost of housing repair and/or renovation and this mounting cost is attributable to the lack of technological progress in the construction industry.

-- Though American transportation is undoubtedly still the most efficient or least costly (in relative terms) in the world, by now it threatens to cover with concrete one-half of the most densely populated areas and in the process of this to destroy much of urban life. No early solution of this problem is anywhere in sight.

-- Though the technology of U.S. defense has been the major preoccupation throughout the 27 years since World War II, in the SALT agreement of 1972 it was concluded that the USSR was on par with the United States in the possession of strategic hardware as well as the overall defense capability. I estimate²⁹ that in the 1950-1955 period the technological base of Soviet military power (production facilities for and/or procurement of military hardware) constituted no more than 20 percent of that of the United States, but, in their drive for the

²⁹Cf., Michael Boretsky, "The Technological Base of Soviet Military Power," Economic Performance and the Military Burden in the Soviet Union, A Compendium of Papers Submitted to the Subcommittee on Foreign Economic Policy of the Joint Economic Committee, Congress of the United States, Washington; 1970, pp. 189-231; and Congressional Record, No. 127, Part III, Vol. 117, August 6, 1971, pp. E 9183 - E 9185.

defense parity, by 1970-1971 the Soviets built up their base in question to the level some 40 percent larger than the U.S. base. In view of U.S. society's present disenchantment with the defense effort, on one hand, and the probability of the Soviets' continuing to procure hardware at the current level--some 40 percent higher than the U.S. level--for some time to come, on another, an increase in the technological sophistication in the civilian sectors would seem to be the only thing that can prevent the United States from becoming a second-rate military power.

-- In the light of all these problems, it is ironic and tragic that in the last couple of years we have permitted some 150 to 250 thousand scientists and engineers to go either unemployed or employed in work other than the field of their specialty.³⁰ The consequence of

³⁰Between 1968 and 1970 the economy-wide employment of "natural" scientists and engineers increased by about 70 thousand, from about 1,525 thousand in 1968 to about 1,595 thousand in 1970 (see National Science Board, Science Indicators 1972, Table 36, p. 123). Since 1970, due to the decline in the economy's R & D in real terms and a rather difficult financial situation in many colleges and universities the level of this employment has been at best stable, and possibly it has declined somewhat. In the academic years 1967-1968 through 1970-1971, according to U.S. Office of Education data, however, the "output" of graduates in natural sciences and engineering (total number of first degrees awarded in academic years 1967/68 through 1970-1971 minus the enrollment for advanced degrees in the fall of 1971) amounted to about 450 thousand. Assuming that from 1968 to 1972 the attrition rate of the employed scientists and engineers averaged about 2 percent per year (as in the 1960-1968 period), and that in 1972 the actual aggregate employment level of this manpower was about the same as in 1970 (1,595 thousand) would imply that this employment would have been short of available manpower in question by about 258 thousand, or some 14 percent of the available total. According to ELS data (see Science Indicators 1972, Table 48, p. 130), however, the actual unemployment rate of scientists and engineers in 1972 was about 2 percent.

this has been not only the loss of what they would have produced in terms of innovations, but also the induced decline in college enrollment of freshman students in natural sciences and engineering by almost one third compared with 1968.³¹ If this reduced enrollment continued for any extended period of time, it would further and severely impair the technological viability of the country for the decades to come.

-- In the light of all these problems, it is also ironic and tragic that there is growing mistrust of science and technology on the part of the general public and an active antitechnology movement within the elite of society--most notably in the universities, the press media, and even in the Government.

³¹According to Engineers Joint Council estimates (June 1973), in the Fall of 1972 freshman enrollment of full-time engineering students numbered 52.1 thousand, or about 33 percent fewer than in the Fall of 1968.

III. CAUSES OF THE LOSS OF U.S. TECHNOLOGICAL ADVANTAGE AND RELATED PROBLEMS

In the face of all the problems I sketched in the preceding section it seems sensible to ask: How did this happen?

Undoubtedly, the causes have been numerous and, I am sure, some of them are unknown. In the broadest terms I would attribute, one way or another, most of these problems to a change in the country's historic posture with respect to technology and the society's (at large) long-term economic self-interest. The most important phenomena through which this overall cause has operated would seem to have been:

1. Relatively lower growth of investment in new industrial plant and equipment in the United States than in other industrialized countries since reconstruction of the most developed foreign economies following World War II;

2. Relatively smaller in volume and rate of growth investment in economically relevant R & D in the United States than in other industrialized countries; and

3. A world-wide and practically one-sided diffusion of existing U.S. advanced technology in a "naked" form.

Each of these three phenomena contributed to the problems in question in a different way and with varying force. The seriousness of these problems is largely a function of the force with which each of the three phenomena affect them and the ease with which the situation could be corrected. Both of these may be judged by the conclusions of the analysis that follows.

Investment in Plant and Equipment

Investment in new industrial plant and equipment is the principal vehicle for the internal diffusion of new technology in the economy and, hence, as I argued earlier, the principal direct force of productivity growth.³² Other things being equal, the faster the real growth in nonresidential (largely industrial) investment the faster will be productivity growth, unless the rate of technological improvements embodied in new investment goods declines over time.

Table 11 lists international disparities in real growth of fixed nonresidential investment in selected periods between 1953 and 1969 (section A), the disparities in real growth of output (GNP) per civilian person employed in selected periods between 1955 and 1971.

³²This proposition is in line with the "embodiment" doctrine proposed by Robert M. Solow in 1962 ("Technical Progress, Capital Formation and Economic Growth," American Economic Review, Vol. 52, No. 3, May 1962, pp. 76-86) and disregards some reported instances of innovations and productivity increases accomplished without increases in investment in the belief that on the whole such cases are unimportant. The most frequently cited instance of increase in productivity without new investment is that of the Horndal iron works in Sweden which increased output per man-hour by over 30 percent over a period of 15 years without additional investment. The instance was originally reported by Erik Lundberg and publicized in the United States by K.J. Arrow in his paper "The Economic Implications of Learning by Doing," Review of Economic Studies, Vol. 29 (3), No. 80, June 1962, pp. 155-173. ILO's publication Methods of Labour Productivity Statistics, Geneva, 1951, pp. 16-29, gives references to several other reports of such instances.

TABLE 11. INTERNATIONAL DISPARITIES IN REAL GROWTH OF FIXED NONRESIDENTIAL INVESTMENT IN 1953-1969
COMPARED WITH REAL GROWTH OF OUTPUT (GNP) PER CIVILIAN PERSON EMPLOYED IN 1955-1971

| Country | A. Average Annual Growth in Fixed Nonresidential Investment, % Per Year | | B. Average Annual Growth in Output (GNP) Per Civilian Person Employed, % Per Year | | C. Ratio of (B) to (A) | |
|--|---|-----------|---|-----------|---|---|
| | 1953-1963 | 1963-1969 | 1955-1965 | 1965-1971 | Growth in Output Per Civilian Person Employed in 1955-1965 to Growth in Nonresi- dential Fixed Invest- ment in 1953-1963 | Growth in Output Per Civilian Person Employed in 1965-1971 to Growth in Nonresi- dential Fixed Invest- ment in 1963-1969 |
| United States | 3.1 | 6.4 | 2.2 | 1.3 | 0.71 | 0.20 |
| France | 9.6 | 8.4 | 5.1 | 4.8 | 0.53 | 0.57 |
| West Germany | 11.1 | 5.4 | 4.5 | 4.3 | 0.41 | 0.80 |
| Belgium-Luxembourg | 5.9 | 5.2 | 2.7 | 3.7 | 0.46 | 0.71 |
| Netherlands | 7.1 | 7.9 | 3.1 | 4.3 | 0.44 | 0.54 |
| Italy | 8.6 | 1.2 | 5.6 | 5.5 | 0.65 | 4.58 |
| COMMON MARKET Countries, Total | 8.9 | 5.8 | 4.6 | 4.8 | 0.52 | 0.83 |
| United Kingdom | 6.3 | 5.2 | 2.1 | 2.8 | 0.33 | 0.54 |
| Canada | 3.0 | 6.0 | 1.9 | 1.8 | 0.66 | 0.30 |
| Japan | 14.8 | 14.2 | 8.0 | 9.6 | 0.54 | 0.68 |
| USSR | 8.7 | 7.9 | 3.5 | 3.6 | 0.40 | 0.46 |
| Unweighted Average for the 10 Foreign Countries | 8.3 | 6.8 | 4.1 | 4.5 | 0.49 | 0.66 |

Sources: See Table 12.

(section B), and the comparison between the two assuming a two-year lag between the investment in new plant and equipment and the growth in productivity (section C).³³ Table 12, in turn, gives the comparison of disparities in fixed nonresidential investment as a percent of GNP in selected years over the same time span.

As is evident in Table 11, in the 1953-1963 period U.S. nonresidential fixed investment grew on the average only about 37 percent as rapidly as that of the foreign countries listed in the table (3.1 percent per year versus simple average for the 10 countries of 8.3 percent) and U.S. output per person employed at the rate about 54 percent of the average for those countries (U.S. 2.2 percent per year versus simple average of 4.1 percent). In the 1963-1969 period, the U.S. lag in the growth in nonresidential investment relative to that of the aggregate of the 10 foreign countries decreased to only about four-tenth's of a percentage point (6.4 versus simple average of 6.8 percent), but the annual growth in U.S. output per man slipped to 1.3 percent per year whereas the (simple) average growth in output per man in the 10 foreign countries increased to 4.5 percent per year making for U.S. ratio of growth in

³³Because of the customary "bugs" in brand new industrial facilities, the lag exists everywhere, but its average length might differ considerably from country to country. The assumption of an average lag of two years made in the comparisons in Table 11 is arbitrary, but any other assumption would not materially change the conclusions of the analysis.

TABLE 12. INTERNATIONAL DISPARITIES IN FIXED NONRESIDENTIAL INVESTMENT AS A PERCENT OF GNP,^{a/} SELECTED YEARS, 1955-1971

| Country | 1955 | 1960 | 1965 | 1969 | 1971 |
|---|------|------|------|------|------|
| United States | 12.1 | 12.0 | 13.1 | 13.1 | 13.1 |
| France | 12.2 | 14.7 | 16.6 | 19.6 | 20.1 |
| West Germany | 16.7 | 18.8 | 21.0 | 21.1 | 21.7 |
| Belgium-Luxembourg | 13.3 | 14.1 | 15.2 | 16.3 | 15.7 |
| Netherlands | 17.8 | 18.9 | 20.2 | 22.1 | 20.8 |
| Italy | 13.8 | 15.5 | 12.4 | 13.1 | 13.7 |
| COMMON MARKET, Total | 14.9 | 16.6 | 17.7 | 18.5 | 19.3 |
| United Kingdom | 10.6 | 12.7 | 14.3 | 14.9 | 14.8 |
| Canada | 17.9 | 18.8 | 19.8 | 18.2 | 18.0 |
| Japan | 15.1 | 23.4 | 26.2 | 31.8 | 31.9 |
| USSR ^{b/} | 18.2 | 23.7 | 26.1 | 27.6 | 29.9 |
| Unweighted Average for the 9 Foreign Countries | 15.1 | 17.8 | 19.1 | 20.5 | 20.7 |

a/ Derived from data in 1963 prices.

b/ Derived from estimates valued in 1963 U.S. dollars.

Sources:

Western Countries: EEC, National Income Accounts 1950-1971; OECD, National Accounts of OECD Countries, 1953-1969; OECD, National Accounts of OECD Countries, 1960-1970; OECD, Main Economic Indicators, selected issues; Statistics Canada, Canadian Statistical Review, selected issues; U.S., Statistical Abstract of the United States, 1972; HMSO, Annual Abstract of Statistics, 1972; OECD, Manpower Statistics 1954-1964, Paris 1971; and OECD, Labour Force Statistics, 1959-1970, Paris 1972.

USSR: M. Bornstein, "A Comparison of Soviet and the U.S. National Product," Comparisons of the United States and Soviet Economies, Joint Economic Committee, Congress of the United States, Part II, 1959; CIA, A Comparison of Capital Investment in the U.S. and the USSR 1950-1959, February 1961 and subsequent unclassified communications; Murray Feshbach, "Manpower in the USSR: A Survey of Recent Trends and Prospects," New Directions in the Soviet Economy, Part III, Joint Economic Committee, 1966, and subsequent communications; and Peter G. Peterson, Secretary of Commerce, U.S.-Soviet Commercial Relationships in A New Era, August 1972. In converting 1955 rubles into 1963 U.S. dollars the following conversion factors were used: GNP—\$1.38 per ruble; nonresidential fixed investment—\$2.00 per ruble.

output per person employed to growth in nonresidential investments to slip to 0.20, from 0.71 in the preceding period, and that of the foreign countries to increase to 0.66, from 0.49 in the preceding period.

This conclusion implies that though the smaller U.S. growth in nonresidential investment must be recognized to have been of importance in the loss of U.S. productivity advantage throughout the post World War II period, it was far more important in the 1950's than in the 1960's. In fact in the 1960's it was, for all practical purposes, only of marginal significance because the real growth in U.S. nonresidential investment lagged behind the average of the foreign countries only insignificantly (4/10 of one percentage point in 1963-1969). The sharp decrease in the U.S. ratio of growth in productivity to the growth in nonresidential investment in the 1965-1971 period implies that in the 1960's of decisive importance was a decrease in the rate of technological improvements embodied in investment goods. This is, of course, consistent with the thesis I advanced earlier, namely, that the decline in U.S. productivity growth since about 1965 relative to the long-term average is in some measure attributable to a decline in the rate of overall technological advance in the economy relative to the past rate, and that the disparity between U.S. productivity growth and that of foreign countries throughout the post World War II period is unquestionably attributable to a relatively faster growth of technological capabilities abroad than in the United States.

This conclusion also implies that any attempt to maintain the relative productivity advantage of the U.S. vis-a-vis foreign countries would require not so much an increase in the U.S. rate of growth in new investments in plant and equipment relative to the average of the foreign countries or thereabout, but a substantial lift-up in the rate of technological improvements to be embodied in newly produced capital goods. This is tantamount to saying that since the rate at which technological improvements are embodied in capital goods, as I argued in the preceding section, is important to the country not only because of its implications for long-term productivity growth (which, on the foreign front, favors only the long-term price competitiveness of domestic industry), but also because of its practically immediate contribution to the technological competitiveness of domestic industry in world markets, and where U.S. industry's position has suffered most, the enhancement of technology should have a much higher priority in U.S. policy making than the enhancement of the investment in plant and equipment. Enhancement of investment in new plant and equipment that is not or at least not much more efficient than the old is not conducive to markedly faster productivity growth and is practically irrelevant for the technological competitiveness of domestic industry in world markets.

Lagging Economically-Relevant R & D³⁴ Effort

Analysis of the comparative international R & D effort is still a relative novelty in economic literature and most of the concepts and analytical procedures promulgated so far are far from established, and quite a few are outrightly erroneous. Perhaps even more important is the fact that what I have to offer differs drastically from prevailing views on the matter as well as the conclusions of other studies, which, of course, have been responsible for these views. It is essential, therefore, that before I proceed with my substantive analysis I explain briefly the concepts I use, especially how they differ from others and why. I think the differences can best be understood if I contrast my concepts with those of other studies on an item by item basis.

³⁴Throughout this section research and development (R & D) is defined to consist essentially of basic and applied research in the sciences and engineering, and the design and development of prototypes and processes. Excluded from this definition are routine product testing, market research, sales promotion, sales service, research in the social sciences or psychology, and other nontechnological activities or technical services. This definition is identical with that used by the National Science Foundation. (See, e.g., National Science Foundation's, Basic Research, Applied Research and Development in Industry, 1964, p. 93). Some of the data which I use in the analysis might not exactly conform with this definition, but I do not think that the deviations, if any, are as great as to invalidate the conclusions.

Briefly stated, most of the published studies of the international comparative R & D effort focus primarily or exclusively on the relative total expenditures on R & D of individual countries derived from estimates of these expenditures in individual countries' national currencies converted into U.S. dollars by means of official exchange rates.³⁵ If additional detail is used, classification of the detail is either unrevealing or it is accorded a highly unimportant role. Based on these studies the view has been formed, both in the United States and abroad, that the R & D effort of the United States exceeds by far that of any other country in the world, and that of all other countries combined except perhaps that of the USSR, not only in the absolute sense, but also relative to the individual countries' resources (GNP). Parenthetically I might add that this view was the basis of the so-called "technological gap" issue which several European statesmen

³⁵ E.g., C. Freeman and A. Young, The Research and Development Effort in Western Europe, North America and the Soviet Union, Paris: OECD, 1965, pp. 91-97; OECD, International Statistical Year for R & D, A Study of Resources Devoted to R & D in OECD Member Countries in 1963/64--Vol. 1, The Overall Level and Structure of R & D Efforts, Paris: 1967; National Science Foundation, National Patterns of R & D Resources. Funds and Manpower in the United States 1953-1972, NSF 72-300, p. 3; Stanford Research Institute, R & D In Europe, Report No. 198, January 1964; Der Bundesminister für Wissenschaftliche Forschung, Bundesbericht Forschung III, 1969, pp. 232-233 and Forschungsbericht (IV) der Bundesregierung, pp. 143-44; and Japanese Science and Technology Agency, White Paper on Science and Technology. Summary; March 1970, pp. 61-76.

raised with President Johnson in 1966 and 1967³⁶ and which was the subject of an extensive debate at the science ministers' meetings at OECD in 1965-1968 as well as a major OECD study published in 1970.³⁷ The issue of the "gap" gradually faded away as the U.S. problems, under discussion in this paper, became increasingly visible. However, it was one of the primary arguments of the United Kingdom in joining the Common Market.

For the analysis of the problems at hand, especially the relative decline in U.S. productivity growth and deterioration in domestic industry's technological competitiveness which is implicit in the deterioration in the U.S. trade position, both the concepts and estimating procedures (as well as the conclusions) of these analyses are totally untenable. In my judgment:

(1) For a country's advance in technological know-how working through productivity as well as the know-how other than that working through productivity and relative prices, which are of concern here, the relevant R & D expenditures are not total expenditures, but only the expenditures on R & D for purposes of what might be defined as "economic development," namely, for purposes of civilian industrial technology, civilian nuclear technology, agriculture, and overall

³⁶ The visitors included Chancellor Erhard of West Germany, Prime Minister Wilson of Great Britain, and Italian Foreign Minister Fanfani.

³⁷ OECD, Gaps in Technology, Analytical Report, OECD: Paris, 1970.

economic infrastructure (transportation, communications and utilities). Expenditures on R & D for purposes of maintenance of health, welfare and the production of know-how for the sake of know-how are only of marginal importance for the analysis at hand, and this only in the long run, and expenditures on R & D for purposes of defense and space exploration have relevance only to the extent to which this R & D yields commercially useful know-how, the so-called "spinoff."

Regarding the "spinoff" we know that some of the most important technological innovations developed since World War II, and which are now in wide use in the civilian sector, have been "spinoffs" of the R & D for defense or space,³⁸ but we also know that between 1941, when the United States first started a large scale R & D effort for defense purposes, and 1971 the United States spent on R & D for defense and space purposes about \$250 billion of 1971 purchasing power, a value greater than the value of the entire fixed business capital stock of West Germany.

³⁸Important examples of spinoff are nuclear reactors, numerically-controlled (N/C) machine tools, jet aircraft, communications satellites and, to some extent, computers. All of these may be categorized as some of the most important "levers" of the U.S. civilian technological advance since World War II. However, most of these came shortly after World War II.

The closest thing to an analytical assessment of the magnitude of civilian "spinoff" which the United States has been deriving from expenditures on R & D for defense and space purposes, that is, how much civilian-technology-equivalent value of innovations the United States has been getting from each dollar spent on R & D for defense and space purposes, was provided by a study of the extent of commercial utilization in 1966 of 2,024 inventions that were developed and patented for the Department of Defense and the Atomic Energy Commission in the 1957-1962 period. This study was prepared in 1968 by Harbridge House, Inc., for the Federal Council on Science and Technology in the context of its review of U.S. patent policies. The study implied that for the purpose of advancing civilian technology the effectiveness of defense and space R & D has been only about 5 percent or so as great as the direct approach. In order not to understate this source of technological progress I assume, for the purpose of my comparisons with other countries' expenditures, that the spinoff has amounted to 10 percent, meaning that out of each dollar the United States, or any other country, spends on R & D for defense and space purposes its civilian know-how is advanced by a magnitude equivalent to the advance had 10 cents been

spent directly on civilian-oriented R & D.³⁹ The aggregate of R & D expenditures containing a portion of R & D expenditures for defense and space which is assumed to yield commercially useable know-how is labeled in my analysis as civilian-equivalent R & D expenditures.

(2) The use of official exchange rates for converting foreign countries' expenditures in their own currencies into U.S. dollars for a comparison with U.S. expenditures is an ultra naive procedure since it assumes that official exchange rates reasonably reflect the various

³⁹The relevant statement in the referenced study reads:
 "...commercial utilization of government-sponsored inventions is very low. Contractors and licensees reported only 251, or 12.4 percent, of all inventions in the survey response in use. Only 55, or 2.7 percent, played a critical role in the commercial products in which they were used, as compared to utilization rates of 50 percent or more estimated for inventions developed under private research."

See, Harbridge House, Inc., Government Patent Policy Study, Vol. I, Final Report, p. I-10. There is, of course, plenty of room for the true magnitude of spin-off to deviate from 5 percent. Most notably, if the average cost of DoD and NASA sponsored inventions is substantially higher than the cost of inventions oriented to commercial markets, and it most probably is, then a 5 percent spin-off is too high. On the other hand, if some of the new commercially applicable know-how developed with DoD, etc., funds is not patented in favor of DoD, but nonetheless used for commercial purposes, and if the actual utilization of privately developed inventions is only about 30 percent rather than 50 percent, as some claim, then a 5 percent spin-off is too low. In all probability it is not greater than 10 percent. I have used the 10 percent assumption in many of my presentations, including to groups containing managers of R & D departments of companies that do R & D for defense and space as well as on their companies' account. Whenever the 10 percent assumption came under discussion, it was termed to be on the "generous" side for DoD and NASA.

currencies' true purchasing power. The recent devaluations of the dollar clearly suggest that they do not reflect them now nor, as we know from Milton Gilbert and Irving Kravis among others,⁴⁰ did they reflect them in the past. To be closer to reality, in my analysis I make comparisons in terms of what I define as U.S.-cost-equivalent expenditures. These represent each country's expenditures in national currencies converted into U.S. dollars by means of official exchange rates and adjusted further by the ratio of the official-exchange-rate dollars' purchasing power in R & D in foreign countries relative to that in the United States. The sources of information for and the magnitude of this adjustment are fully explained in footnote (b) to Table 13. Briefly stated, the methodology of my estimating the various countries' expenditures on R & D in U.S.-cost-equivalent dollars parallels the estimating of various countries' GNP in comparable "purchasing power equivalents" pioneered by Milton Gilbert and Irving Kravis in the studies referenced in footnote 40.

⁴⁰Cf., e.g., Milton Gilbert and Irving B. Kravis, "An International Comparison of National Products and the Purchasing Power of Currencies, OEEC, Paris, 1954; M. Bornstein, "A Comparison of Soviet and the U.S. National Product," Comparisons of the U.S. and Soviet Economics, Joint Economic Committee, Congress of the United States, part II, Washington, 1959; Japanese Bureau of Statistics, Kokumin Seikatsu Hakushi (National Life White Paper) Tokyo, 1965, Section I-2, Table 2.

(3) For the problem at hand the primary objective of comparing R & D expenditures, however they are measured, is not only to learn the differences in the magnitude of the expenditures per se, but, and primarily, the differences in probable magnitude of the output of the R & D effort--the inventions, for which no comprehensive statistics are available. Chances are that the comparative employment of R & D manpower might be a better approximation of the latter than expenditures. For this reason I also focus on the comparative employment of professional manpower in R & D.

I define "professional manpower" to consist of scientists, engineers and technicians. The inclusion of technicians is emphasized because some analysts consider that only "qualified scientists and engineers" belong in the category of professional manpower. For reasons of international differences in educational systems and classification of graduates, the use of this limited concept in international comparisons has tended to produce grossly misleading conclusions. In the United States, for example, a researcher who had completed 4 years of high school and 4 years of college for which he received a B.S. degree is automatically classified as a "qualified" scientist or engineer; in Germany a researcher with a similar amount of schooling would have completed only some sort of technikum and he is classified as technician. Comparisons of U.S. R & D manpower inclusive of all people with B.S. degrees and German R & D manpower exclusive of those who completed only technikum yield biased results.

In comparisons of the United States R & D effort over time, however, the use of either of the two concepts does not make much difference.

(4) I also consider it essential to focus not only on the foreign countries' magnitudes of R & D effort in question relative to the United States (measured by the expenditures on R & D in U.S.-cost-equivalent dollars and the employment of professional manpower in R & D), but also on these countries' intensity of R & D relative to the United States. Other analysts measure the individual countries' intensity of R & D effort simply by the ratios of their expenditures on R & D to GNP and/or their employment in R & D to total population. I consider it to be more instructive, however, to measure the foreign countries' relative intensity of R & D effort by the ratios of their magnitude of R & D effort relative to the U.S. (expenditures on R & D and employment of professional manpower in R & D) to these countries' magnitude of GNP relative to the United States. The difference is substantial and the latter much more revealing. For example, in 1967 Japan's employment of professional manpower in R & D represented 58 percent of that of the United States, but in the same year its GNP was only 20.3 percent of the U.S. GNP (both measured in dollars of roughly the same purchasing power). Consequently, Japan's intensity of R & D efforts, relative to the United States measured by the employment of professional manpower in R & D, is estimated to have been 2.86 times as great as the U.S.

intensity ($58 + 20.3 = 2.86$). In simple terms, I define this concept as the "R & D effort per dollar's worth of GNP relative to the United States" (U.S. = 1.00).

Bearing the meaning of these concepts in mind, we might proceed with the substantive analysis.

Statistical data on most foreign countries' R & D effort are published after much delay and no foreign country publishes comprehensive data on a regular basis. In the 1960's, however, OECD published the results of two extensive surveys of R & D effort in member countries in 1963-1964 and 1967 which, in my judgment, permit a reasonably accurate assessment of the overall comparative effort of concern here in practically all Western countries in the 1960's. Using the concepts explained above, these data are summarized in Table 13.⁴¹

This table indicates that though the United States was spending on and employing more professional manpower in economically-relevant R & D than any other single country, the relative intensity of this R & D effort can hardly be classified as that of a leader. Indeed,

⁴¹In the middle of 1972, OECD published the results of its survey of the R & D effort in member countries in 1969, but incorporations of these data into Table 13 would not materially change the conclusions regarding the comparative R & D effort in the 1960's based only on the data for 1963/64 and 1967.

TABLE 13. COMPARATIVE CIVILIAN-EQUIVALENT R & D EFFORT FOR PURPOSES OF ECONOMIC DEVELOPMENT^{a/}
IN THE 1960's: U.S. VERSUS SELECTED INDUSTRIALIZED COUNTRIES

| Country | Expenditures (Average For 1963-1967) | | | Employment of Professional Manpower ^{c/} (1967) | | |
|--|--|--------------------------|--------------------------------------|--|--------------------------|--------------------------------------|
| | \$Millions (U.S.-Cost- Equivalent) ^{b/} | % of U.S. U.S.=100 | Per \$ Worth of GNP, U.S.=1.00 | Thousands (Full-Time- Equivalent) | % of U.S. U.S.=100 | Per \$ Worth of GNP, U.S.=1.00 |
| United States | 7,992 | 100 | 1.00 | 342.5 | 100 | 1.00 |
| France | 1,750 | 22 | 1.35 | 78.5 | 23 | 1.37 |
| West Germany | 2,098 | 26 | 1.44 | 100.7 | 29 | 1.61 |
| Belgium | 195 | 2 | 0.69 | 10.8 | 3 | 1.00 |
| Netherlands | 482 | 6 | 1.82 | 26.9 | 8 | 2.42 |
| Italy | 420 | 5 | 0.50 | 27.3 | 8 | 0.79 |
| Common Market | 4,945 | 62 | 1.22 | 244.2 | 71 | 1.38 |
| United Kingdom | 2,132 | 27 | 1.69 | 116.3 | 34 | 2.17 |
| Western Europe, Total | 7,972 | 100 | 1.14 | 402.5 | 118 | 1.34 |
| Canada | 406 | 5 | 0.64 | 24.2 | 7 | 0.88 |
| Japan | 1,667 | 21 | 1.21 | 197.9 | 58 | 2.86 |
| Western Europe, Canada and Japan, Total | 10,045 | 126 | 1.12 | 624.6 | 182 | 1.56 |

a/ R & D for purposes of agriculture, civilian nuclear technology, civilian industrial technology infrastructure, and civilian-equivalent R & D performed for defense and space purposes, assumed to amount to about 10% of the latter (see text for rationale of this assumption).

b/ Expenditures in currencies of individual countries converted into U.S. dollars by means of official exchange rates in force in 1965 adjusted for the relative cost of R & D in dollars in the United States vis-a-vis the other countries. The adjustment is in line with the argument advanced by C. Freeman and A. Young in their pioneering study published in 1965 (The Research and Development Effort in Western Europe, North America and the Soviet Union. An Experimental Comparison of Research Expenditures and Manpower in 1962, Paris: OECD, 1965), namely, that international comparisons of R & D efforts based on expenditures in official-exchange-rate dollars might not be meaningful since the dollar's purchasing power in R & D was probably much greater abroad than in the United States. On the implicit assumption of about the same productivity of R & D manpower in the

TABLE 13, Continued

United States as abroad, Freeman and Young estimated that in 1962 the U.S. dollar might have bought some 80 percent more R & D in the United Kingdom than in the United States; in France, about 49 percent more; in West Germany, 72 percent more; in Belgium, 70 percent more; and in the Netherlands, about 82 percent more (see ibid., pp. 91-92). These estimates imply that in 1962 the dollar might have bought on the average some 67 percent more R & D in Western Europe than in the United States. This hypothesis is supported by the experiences of at least 116 major U.S. companies engaged in R & D in both Western Europe and the United States. In a Department of Commerce survey on "Experiences and Practices of U.S. Corporations in Western Europe" (Bureau of the Budget Form No. 41-567036) conducted in 1967 the 116 companies reported that in 1965-1966 their dollar cost of comparable R & D personnel in Western Europe was on the average about 58 percent of that in the United States and the dollar overhead cost per average R & D person was estimated at about 78 percent of the U.S. level. Weighting these two estimates with the typical shares of these two cost elements in the total R & D cost in Europe and the United States (60 and 40 percent, respectively) implies that in 1965-1966 the companies' dollar cost of R & D (total) in Western Europe was at a level about 66 percent of that in the United States, or that the dollar's purchasing power in R & D was about 52 percent higher in Western Europe than in the United States. Inasmuch as U.S. companies operating in Western Europe tend to pay somewhat higher salaries than local companies and that the experiences of these companies refer to 1965-1966 rather than 1962, I consider the Freeman-Young estimates to be fully consistent with the experience of U.S. companies and, probably, as close to reality as one may get.

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Using methodology and data analogous to those used by Freeman and Young I estimate that in 1965, to which the data posted in the table refer (average of 1963 and 1967), the dollar cost of R & D in Western Europe was at a level about 62 percent of that in the United States; in Canada, about 90 percent of the U.S. level; and in Japan, about 58 percent of the U.S. level. These are the adjustment factors which I used in converting the estimates of the individual countries' R & D expenditures in question in official exchange-rate dollars into "U.S.-cost-equivalent" dollars and which are posted in the table.

c/ The concept of professional manpower includes qualified scientists, engineers, and technicians.

Source of data on the individual country's expenditures in national currencies and full-time-equivalent employment of professional manpower: OECD, International Statistical Year for R & D, A Study of Resources Devoted to R & D in OECD Member Countries in 1963/64--Vol. 1; The Overall Level and Structure of R & D Efforts, Paris, 1967; Vol. 2: Statistical Tables and Notes, Paris, 1968; and International Survey of the Resources devoted to R & D in 1967 by OECD Member Countries, Vol. 5, Statistical Tables and Notes, Paris, 1970.

in terms of expenditures its relative intensity--per dollar's worth of available resources (GNP)--was only about 80 percent as great as that of the Common Market countries and Japan, and only about 60 percent as great as that of the United Kingdom. Measured by the number of professional manpower employed in this R & D, the relative intensity of the U.S. effort was almost 30 percent smaller than that of the Common Market countries, less than half that of the United Kingdom, and only about 35 percent of that of Japan.

This is tantamount to saying, ironically, that if in the 1960's any country's economically-relevant R & D performance could be described to have had the characteristics of a "gap," the description should have been accorded the United States rather than the major countries in Europe or Japan. Indeed, considering the fact that the United States depends more on internal R & D for its progress than any other country, because it is still more technologically advanced than any other country and is therefore unable to sustain its rate of progress by importing much advanced technology from abroad but performs relatively less than the other countries, such description would hardly have been an overstatement. Moreover, it seems almost certain that by now this U.S. lag in R & D relative to other industrialized countries has appreciably increased rather than narrowed.

Regarding this I refer to Table 14. The table shows the trends in the U.S. industrial R & D effort (the key component of what is labeled in Table 13 as economically-relevant R & D) since 1953, total and by sponsor--Government and private companies--measured by current

TABLE 14. TRENDS IN U.S. INDUSTRIAL R & D EFFORT: SELECTED YEARS, 1953-1971

| Year and Item | Total Industrial R & D Effort | | R & D Effort Financed by Federal Government (Largely DoD and NASA) | | R & D Effort Financed by Private Company Funds ^{b/} | |
|---|---|--|--|--|--|--|
| | Expenditures, \$ Billions (Current) | Employment of R & D Scientists and Engineers, Thousands (Full-Time- Equivalent) | Expenditures, \$ Billions (Current) | Employment of R & D Scientists and Engineers, Thousands (Full-Time- Equivalent) | Expenditures, \$ Billions (Current) | Employment of R & D Scientists and Engineers, Thousands (Full-Time- Equivalent) |
| 1953 | 3.6 | 132.0 ^{c/} | 1.4 | 45.0 ^{a/} | 2.2 | 87.0 ^{a/} |
| 1957 | 7.7 | 236.6 | 4.3 | 112.1 ^{a/} | 3.4 | 124.5 ^{a/} |
| 1963 | 12.6 | 333.8 | 7.3 | 161.7 | 5.3 | 172.1 |
| 1969 | 18.3 | 385.6 | 8.5 | 154.2 | 9.9 | 231.4 |
| 1971 | 18.3 | 362.4 | 7.6 | 124.6 | 10.5 | 237.8 |
| Average Annual Growth Rates, % per Year | | | | | | |
| 1953-1957 | 21.0 | 15.7 | 32.5 | 25.5 | 11.5 | 9.4 |
| 1957-1963 | 8.6 | 5.9 | 9.2 | 6.3 | 7.7 | 5.6 |
| 1953-1963 | 13.3 | 9.7 | 18.0 | 13.7 | 9.2 | 7.0 |
| 1963-1969 | 6.4 | 2.4 | 2.6 | -0.8 | 9.3 | 5.1 |
| 1969-1971 | 0.0 | -3.0 | -5.5 | -10.1 | 3.0 | 1.4 |

Table 14, Continued

- a/ Estimated by the author on the basis of historical differences in expenditures per scientist and engineer in government-sponsored R&D vis-a-vis projects funded by the companies themselves.
- b/ The company expenditures and employment do not include small company-financed R&D contracted to outside organizations such as research institutions, universities and colleges, etc. In 1970, for example, industrial firms contracted \$243 million of R&D to outside organizations, or 2.4 percent of the R&D performed by the companies themselves.
- c/ Average for 1952 and 1954.

Sources:

U.S. Department of Labor, Bureau of Labor Statistics, Scientific Research and Development in American Industry: A Study of Manpower and Costs, Bulletin No. 1148 (Washington, D.C., GPO, 1953) pp. 14 and 59; U.S. National Science Foundation, National Patterns of R&D Resources, Funds and Manpower in the United States, 1953-1972 (Bulletin NSF 72-300); _____, Research and Development in Industry, 1970 (Bulletin NSF 72-309) and 1971 (forthcoming).

dollar outlays and the employment of scientists and engineers (the inclusion of technicians, as noted earlier, would not make much difference in this case). For the problem at hand, the most indicative is the R & D financed by private companies (right side of the table) because Government-financed R & D is largely oriented toward the needs of the Department of Defense and NASA and this effort only sporadically produces know-how useable in civilian markets (by the way of "spin-off"). By the type of measure, expenditures versus employment of scientists and engineers, the more revealing for the trend in the real effort is employment because R & D activity is not known for spectacular growth of productivity (innovations per professional man employed in R & D), but it is known to have been a substantial source of inflation, most notably in the initial years of the period.⁴² The table indicates that after a rapid spurt in U.S. research and development for purposes of industrial technology in the 1953-1957 period and fairly rapid gain between 1957 and 1963 (9.2 percent per year in 1953-1963—in terms of expenditures, and 7.0 percent in terms of S & T manpower), the real rate of expansion, as indicated by the growth of employment in company-financed R & D, slowed to no more than 5.1 percent per year between

⁴²Cf., J. Herbert Hollomon and Alan E. Harger, "American Technological Dilemma," Technology Review, Vol. 73, No. 9 (July/August, 1971), pp. 31-40.

1963 and 1969, and to no more than 1.4 percent per year in the 1969-1971 period. With the drastic curtailment of Government-sponsored R & D in this period (over 20 percent in terms of employment of scientists and engineers), which implies a proportionate decline in the potential generation of spinoffs, the 1969-1971 real growth in total United States R & D effort for purposes of civilian industrial technology might be assumed to have been about zero.

At the time of this writing, consistent data on R & D performed in industry ("business enterprise sector" in OECD terminology) for all foreign countries specifically listed in Table 13 are available only for 1963-1964, 1967 and 1969. The comparative growth rates between 1963 and 1969 computed from these data are posted in Table 15. The table shows that industrial R & D in the 1963-1969 period was growing faster in all major foreign countries except the United Kingdom than in the United States. Since the relative intensity of British R & D (per dollar's worth of GNP) was about double that of the United States and substantially higher than in most other countries throughout the 1960's (Table 13), however, the lack of growth in the British R & D effort in that period might be considered as inconsequential.

For the 1969-1971 period, that is, the period of practically zero growth in the U.S. industrial R & D effort (Table 14), at the time of this writing we have fairly current data for only Japan and West Germany. In that period Japan's "head count" of full-fledged researchers (net of technicians) working in industrial R & D increased

TABLE 15. COMPARATIVE GROWTH IN TOTAL INTRAMURAL R & D EFFORT^{a/} PERFORMED
IN THE BUSINESS ENTERPRISE SECTOR OF SELECTED COUNTRIES, 1963-1969

| Country | Percent per Year | |
|----------------------|---|---|
| | Growth of R & D Expenditures (Current Prices) | Growth in Employment of Professional R & D Manpower ^{b/} |
| United States | 5.6 | 3.5 |
| France | 16.0 | 6.6 |
| West Germany | 15.0 ^{c/} | 6.6 ^{c/} |
| Belgium | 8.0 | 2.5 |
| Netherlands | 14.7 ^{c/} | 13.2 ^{c/} |
| Italy | 13.1 | 6.2 |
| Common Market, Total | 14.9 | 6.7 |
| United Kingdom | 6.2 ^{c/} | 0.1 ^{d/} |
| Sweden | 6.1 ^{c/} | 3.2 ^{c/} |
| Norway | 13.4 | 8.6 |
| Austria | 20.5 | 13.2 |
| Canada | 12.7 | 4.9 |
| Japan | 20.0 | 5.3 |

a/ All sources of funding, including capital expenditures in the case of foreign countries and depreciation in the United States.

b/ Scientists, engineers and technicians.

c/ 1964-1969

d/ 1965-1968

Sources:

OECD, A Study of Resources Devoted to R & D in OECD Member Countries in 1963/64, Vol. 2, Statistical Tables and Notes, Paris, 1968; and OECD, International Survey of the Resources Devoted to R & D in 1969 by OECD Member Countries, Vol. 1, Business Enterprise Sector, Paris, 1972.

CD

by about 35 percent, or about 16 percent per year (cumulative).⁴³ This implies a tremendous acceleration in Japan's R & D effort both relative to its own past performance and relative to other countries, especially relative to the United States. West Germany's R & D expenditures by industry (Wirtschaftssektor) alone increased in the two years by 20.3 percent, or 9.7 percent per year (cumulative) in current prices, and, probably, some 2.2 percent per year (cumulative) in real terms. The total West German R & D expenditures in the 1969-1971 period, which are largely civilian-market oriented, however, increased by about 14 percent per year (cumulative) in current prices and, probably, some 6 percent per year in real terms.⁴⁴

Throughout this analysis I have attempted to utilize only aggregative (macro) data since even a small portion of detail would tend to swell this paper into a full-sized book or two. In view of the importance of the U.S. gap in R & D performance I should like to make an exception to this overall attempt by referring to comparative trends

⁴³Office of the Prime Minister, Statistics Bureau, Survey on Science and Technology, 1972, p. 333. (The source is in Japanese. Translation of the headings of relevant statistical tables was kindly provided by Professor Terutomo Ozawa of Colorado State University.)

⁴⁴The data on German R & D expenditures in current prices are from Der Bundesminister für Bildung und Wissenschaft, Forschungsbericht (IV) der Bundesregierung, Bonn, 1972, p. 202. The estimates of "real" rates of growth represent the respective percentage increases in current prices deflated with percentage increases in the GNP deflator.

that are underway in the industry that literally "swings the U.S. economy"--the automobile industry. The available data are provided in Table 16. The table shows that between 1964 and 1969 the real R & D effort (employment of professional manpower) of the three foreign countries' automobile industries (West Germany, France, and Japan) had grown more than 2 times as rapidly as that of U.S. industry and that the combined effort of the three countries in question grew from 113 percent of the United States in 1964 to 165 percent in 1969. From a different source we also know that in the middle of the 1960's the size of the U.S. automobile industry, in terms of the value of output, exceeded the aggregate of West Germany, France and Japan by about 80 percent, but by 1970 the size of the U.S. industry was about 20 percent smaller than the aggregate of the three countries.⁴⁵ In view of the recession and a drastic decline in automobile production in the United States in 1970⁴⁶ but fairly normal conditions abroad, we might presume that in 1969 the size of U.S. automobile industry was about as large as the aggregate of the three other countries. This implies that in the middle of the 1960's the relative intensity of the R & D effort in

⁴⁵See The Oriental Economist, October 1971, p. 21

⁴⁶The Bureau of Economic Analysis estimate of the value of domestic new car output (sales) in 1958 prices in 1970 was about 20 percent smaller than in 1969. See Survey of Current Business, March 1971, p. 10.

TABLE 16. COMPARATIVE EMPLOYMENT OF PROFESSIONAL MANPOWER (SCIENTISTS, ENGINEERS AND TECHNICIANS) IN THE R & D OF MOTOR VEHICLES AND RELATED PRODUCTS INDUSTRIES: SELECTED COUNTRIES, 1964 AND 1969

| Country | Actual Number Employed | | Average Annual Growth from 1964 to 1969, Percent per Year |
|--|------------------------|--------|---|
| | 1964 | 1969 | |
| United States | 12,900 | 17,100 | 5.8 |
| West Germany | 7,081 ^{a/} | 8,903 | 4.7 |
| France | 2,552 | 6,617 | 21.0 |
| Japan | 4,966 | 12,742 | 20.7 |
| West Germany, France and Japan, Total | 14,629 | 28,262 | 14.1 |
| Ditto, % of U.S. (U.S. = 100) | 113 | 165 | 7.9 |

a/ In 1964 German data on employment of professional manpower in automobile industry was combined with employment in nonelectrical machinery, shipbuilding and other transport equipment, but in 1969 this total was disaggregated. The posted estimate assumes that in 1964 the proportion of the employment in automobile industry in the total of machinery, etc., was the same as in 1969.

Sources:

U.S. Department of Labor, Bureau of Labor Statistics, Scientific and Technical Personnel in Industry, Bulletin No. 1609 (1961-1966) and No. 1723 (1969); OECD, A Study of Resources Devoted to R & D in OECD Member Countries in 1963/64, Vol. 2, Statistical Tables and Notes, Paris, 1968, and International Survey of the Resources Devoted to R & D in 1969, Statistical Tables and Notes, Vol. 1 (Business Enterprise Sector), Paris 1972.

the three foreign countries' automobile industries was only about two-thirds as great as that of the United States, but by 1969, a mere five years later, it was almost two-thirds greater than the relative intensity of the R & D effort in the United States.

The R & D effort, however measured, constitutes only an input in a country's "inventiveness" which is the thing that makes the difference for the country's growth in the technological know-how and, hence, growth in productivity and international competitiveness. Data on patents issued by the U.S. Patent Office to and applications received from U.S. and foreign residents shown in Table 17 strongly imply, however, that the gap is probably similar in actual inventiveness. Parenthetically, I should note that in interpreting these patent data the more revealing are the trends in patents issued and/or applied for by U.S. residents versus foreign residents rather than the relative numbers of patents issued and/or applied for because U.S. residents tend to file patent applications for all types of inventions whereas foreign residents usually seek the protection of U.S. patents for only the most important inventions.^{46a}

There are other data that might be used and which point to the same thing. For the automobile industry alone, we know, for example, that the greater R & D effort abroad has yielded most of the major

^{46a}For exceedingly instructive trends in the relative numbers of patents being issued by the U.S. Patent Office to foreign versus U.S. applicants in a number of specific areas of technology see U.S. Department of Commerce, Technology Assessment and Forecast, Initial Publication of the Office of Technology Assessment and Forecast, April 1973.

TABLE 17. PATENTS ISSUED BY THE U.S. PATENT OFFICE TO AND PATENT APPLICATIONS RECEIVED FROM U.S. RESIDENTS AND RESIDENTS OF FOREIGN COUNTRIES: SELECTED CALENDAR YEARS, 1961-1971

| Item | 1961 | 1963 | 1965 | 1967 | 1969 | 1970 | 1971 |
|--|--------|--------|--------|--------|--------|---------|---------|
| <u>PATENTS ISSUED</u> ^{1/} | | | | | | | |
| Total | 48,368 | 45,681 | 62,857 | 65,652 | 67,557 | 64,427 | 78,316 |
| --To U.S. residents | 40,154 | 37,176 | 50,332 | 51,274 | 50,395 | 47,073 | 55,988 |
| --To residents of foreign countries | 8,214 | 8,505 | 12,525 | 14,378 | 17,162 | 17,354 | 22,328 |
| --Foreign as percent of U.S. | 20.5 | 22.9 | 24.9 | 28.0 | 34.1 | 36.9 | 39.9 |
| <u>PATENT APPLICATIONS</u> ^{2/} | | | | | | | |
| Total | 83,100 | 85,724 | 94,629 | 87,872 | 98,386 | 102,868 | 104,566 |
| --By U.S. residents | 66,039 | 66,570 | 72,303 | 63,826 | 67,879 | 72,036 | 70,926 |
| --By residents of foreign countries | 17,061 | 19,154 | 22,326 | 24,046 | 30,507 | 30,832 | 33,640 |
| --Foreign as percent of U.S. | 25.8 | 28.8 | 30.9 | 37.7 | 44.9 | 42.8 | 47.4 |

1/ Excludes plants, designs, and reissues.

2/ Includes reissues, excludes plants and designs.

Sources:

Commissioner of Patents, Annual Report, Fiscal Year 1971; ibid, Fiscal Year 1972; and Bureau of the Census, Statistical Abstract of the United States, 1972

technological innovations in the automobiles in the 1960's⁴⁷ as well as viable options for the control of auto pollutant⁴⁸ compared to the viable options not produced by U.S. industry. Most important of all, these data are fully consistent with totally independent estimates of the relative decline in productivity and the technological competitiveness of U.S. industry at large as well as a host of other problems which I discussed earlier.

Having noted this I should hastily note also, however, that because of the usual time lag between R & D projects and wide diffusion of their results in the economy (four to ten years) I do not believe that the U.S. R & D gap relative to the other industrialized countries outlined in the preceding pages has already exerted its full impact on the lower rate of U.S. productivity growth and the losses in competitive advantage in world markets. The full impact of this gap on both is yet to come.

⁴⁷E.g., disc brakes, fuel injection, radial tires, rotary engine, and, probably, the stratified charge engine.

⁴⁸Mazda and Honda.

U.S. Export of Advanced Manufacturing Technology in a "Naked" Form

By "naked" export of technology I mean sales of this technology in the form of patent rights and licenses, together with appropriate instructions, blueprints and other technical assistance on the part of the seller to assure exploitation of the know-how, for a fixed or "running" fee rather than the export of such technology embodied in products manufactured in the United States. The consequences of this export is an extremely controversial and sensitive problem, both domestically and internationally. Most of those engaged in such exports, and great many others, argue that these exports are a "natural" result of the maturity of our economy; without these exports U.S. companies could not be competitive in their foreign operations; and that it is in U.S. national interest to continue to do so because these exports benefit the exporting companies and the country's balance of payments. However, there would seem to be also as many people, if not more, who maintain that these exports represent the substitution for exports of products from the United States and, hence, the exportation of U.S. jobs, and that they constitute a major factor in the deterioration in U.S. merchandise trade and balance of payments. In the face of this controversiality, and, even more importantly, the sensitivity of the issue, I almost wish that I somehow could avoid discussing it. In view of the theory of international trade which I advance in this paper, and the relative importance of the consequences of these exports for the deterioration of U.S. trade which is discernable in the context of this theory, however, there is no way I could evade it.

Analyzed in the context of my theory, the consequences of U.S. exports of advanced technology in a "naked" form depend on the nature of economic activity abroad in which the technology in question is used and whose interest is considered.⁴⁹ Exports of advanced technology useable in areas of foreign economic activity which are supplementary or noncompetitive with U.S. economic activities (such as extractive industries, utilities and retail trade) tend to benefit the importing country, the companies exporting it, and the United States at large. The reason for the benefit of the importing country is that these imports tend, by the definition of "advanced technology," to enhance the productivity and, hence, real income, and they are frequently the sine-qua-non of the economic activity in question; and the reason for U.S. benefits is that such exports of technology command fees that otherwise would not be forthcoming to the companies and the United States, and if the technology in question is used in the production of products which the United States is importing this technology tends to

⁴⁹As Paul B. Simpson of Oregon University persuasively demonstrated more than ten years ago, the same is largely also true with the export of capital. See his "Foreign Investment and the National Economic Advantage: A Theoretical Analysis" in U.S. Private and Government Investment Abroad, Raymond F. Mikesell (ed.), Eugene, Oregon: University of Oregon Books, 1962, pp. 503-538.

keep the cost of these products down and thus secure better "terms of trade" for the United States than otherwise would be the case. However, exports of advanced technology useable in areas of foreign economic activity competitive with the activities of the United States, such as the manufacture of internationally traded goods, tend to be advantageous to the importing country and to the exporting companies, but detrimental to the well-being of the United States at large. The reason why the United States at large gets the short end of the deal is that the technology in question is usually new and thoroughly market-tested, the demand for products embodying this technology tends to be highly or at least fairly inelastic (by the definition of new and market-tested technology), and, its export in a "naked" form, though commanding fees and in many instances conducive to some exports of products from the United States (capital goods and some components impractical to produce abroad), tends on the whole to be substitute for exports of products from the United States as well as (at least in long run) a promoter of competitive imports. The value of the latter two ("displaced" exports plus promoted imports) tends to be much greater than the returns of fees and promoted exports of products even in cases where the would-be exports of the products embodying the technology from the United States were appreciably smaller than the sales of these products when produced abroad. The discrepancies in the relative magnitudes in question have implications not only for trade and balance payments, but also for employment, treasury revenues and many other variables.

The preceding qualitative analysis is quantitatively amplified by the illustrative operations-research-type calculations presented in Table 18. The meaning of these calculations, with the accompanying notes explaining how they were derived, should be self-explanatory.

The extent and growth of actual exports of U.S. technology in a "naked" form by major type between 1960 and 1970 might be judged by U.S. companies' receipts from and payments to foreign countries for technological royalties and license fees by industry shown in Table 19 and Chart 3. The estimates include the companies' transactions with foreign companies as well as their foreign affiliates.

In analyzing the companies' receipts for manufacturing technology given in Table 19 it might be assumed that, on the average, they represent about 4 percent or so of the value of products based on this

TABLE 18. ILLUSTRATIVE CALCULATIONS OF THE IMPLICATIONS OF
EXPORT OF TECHNOLOGY IN A "NAKED" FORM

PART I. Suppose country N were to estimate that in the next 4 to 5 years it would need or could use 25 to 30 additional currently provided and highly competitive U.S. commercial air liners--25 at U.S. price per unit (about \$25 million per airplane), and 30 if the unit price were some 30 percent lower (which assumes country N's price demand elasticity for this type of product is about 0.5). The price would be 30 percent lower if the airplane were produced in lower wage country N rather than in the United States. To achieve the latter, lower wage country N offers to buy the complete package of the know-how from the U.S. companies manufacturing the airplane (the airframe, engines, and the associated equipment) for its own limited use at a price of \$1 million per unit produced. Inasmuch as the price for the know-how which country N offers represents a greater percentage of the companies' earnings relative to their sales than they averaged in the last 10 years (about 3.0 percent) the U.S. companies accept the offer.

Implications of the Licensing for the U.S. Companies
and to the United States

| Item | (A) Licensing to Country N | (B) Would-be Production in and Export from the U.S. | (C) Ratio of (A) to (B) |
|--|-------------------------------|--|----------------------------|
| 1. Profits to U.S. Companies, \$ Millions | 30.0 ^{a/} | 18.8 ^{b/} | 1.59 |
| 2. U.S. Exports, \$ Millions | -- | 625.0 ^{c/} | -- |
| 3. Imports to the U.S., \$ Millions | -- ^{d/} | -- | -- |
| 4. Employment in the U.S., Thousand Man-Years | -- ^{e/} | 37.5 ^{d/} | -- |
| 5. Payroll in the U.S., \$ Millions | ... ^{e/} | 470.0 ^{f/} | -- |
| 6. Receipts of U.S. Treasury, \$ Millions | 14.4 ^{g/} | 56.0 ^{h/} | 0.26 |
| 7. Balance of Payments, \$ Millions | 30.0 | 625.0 | 0.05 |

TABLE 18. ILLUSTRATIVE CALCULATIONS OF THE IMPLICATIONS OF
EXPORT OF TECHNOLOGY IN A "NAKED" FORM--Continued

Notes to Part I:

- a/ 30 units @ \$1 million.
- b/ 3 percent on \$625 million (= 25 units @ \$25 million).
- c/ 25 units @ \$25 million.
- d/ Employment at U.S. aircraft plants and suppliers, estimated to be 60 thousand jobs per \$1 billion of sales, net of multiple counting.
- e/ Negligible (technicians advising Country N in setting up production).
- f/ 37.5 thousand jobs times \$12,500.
- g/ 48 percent of \$30 million.
- h/ 10 percent of payroll (\$47.0 million) plus 48 percent of profit (\$9.0 million).
- i/ Assumed to be zero under the terms of the agreement. In the long-run, however, the enhancement of foreign know-how would tend to produce competitive imports to the United States. The best example of this tendency is U.S. trade in products based on electronics technology (electronics, communications equipment other than computers, and phonographic and sound reproduction equipment). The bulk of all new technology developed in this product group since World War II has come from the United States (beginning with Bell Lab's transistors in 1947), much of which has been paid for by the Government. U.S. companies diffused this technology as rapidly as they could and our trade situation took a predictable swing: in 1960 we had a trade surplus in this product group of about \$200 million, by 1965 this surplus shrank to about \$100 million, by 1971 we had already a deficit of \$722 million, and in 1972 the deficit amounted to \$1,077 million.

TABLE 18. ILLUSTRATIVE CALCULATIONS OF THE IMPLICATIONS OF
EXPORT OF TECHNOLOGY IN A "NAKED" FORM—Continued

PART II. Suppose that instead of selling the licenses to country N, the U.S. companies in question are permitted to set up their jointly-and wholly-owned manufacturing subsidiary in country N. In line with the common practice of U.S. based multinational companies in developed countries^{a/} the subsidiary would probably service not only country N, but also a part of the adjoining geographic area and a small proportion of its output would be exported to the United States. Assuming all this, the implications for the U.S. companies in question and the United States would probably be as follows:

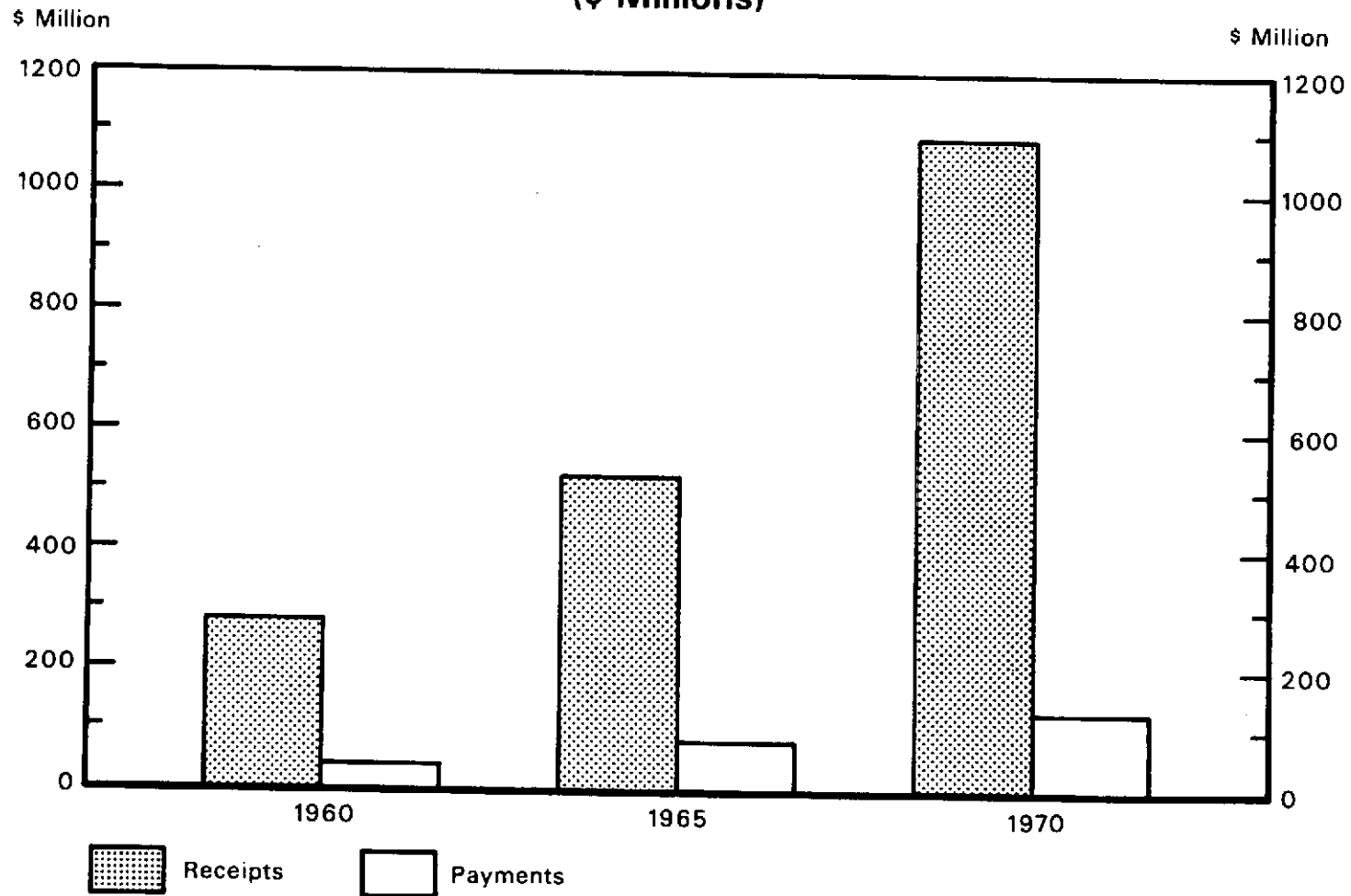
| Item | (A) Subsidiary in Country N | (B) Would-be Production in and Export from the U.S. | (C) Ratio of (A) to (B) |
|---|--------------------------------|--|----------------------------|
| 1. Sales of the Companies | 827.0 ^{b/} | 792.0 ^{c/} | 1.044 |
| 2. Earnings | | | |
| a. Receipt of Royalties, \$ Millions | 28.6 ^{d/} | — | — |
| b. Management Fees | 16.3 ^{e/} | — | — |
| c. Profits after Foreign Taxes | 34.7 | — | — |
| d. Total Earnings to the Companies (Sum of Items 2a-2c) | 79.6 | 23.7 ^{f/} | 3.36 |
| 3. Export from the U.S. | 112.0 ^{h/} | 737.0 ^{i/} | 0.15 |
| 4. Import to the U.S. | 65.0 ^{j/} | — | — |
| 5. Employment in the U.S., Thousand Man-Years | 6.7 ^{k/} | 47.5 ^{l/} | 0.14 |
| 6. Payroll in the U.S., \$ Millions | 83.8 ^{m/} | 593.8 ^{n/} | 0.14 |
| 7. Receipts of U.S. Treasury | 31.3 ^{o/} | 70.8 ^{p/} | 0.44 |
| 8. Capital Transfer, \$ Millions | 135.0 ^{q/} | — | — |
| 9. U.S. Balance of Payments, \$ Millions | | | |
| a. Earnings abroad ^{r/} | +79.6 | — | — |
| b. Export from U.S. | +112.0 | +737.0 | — |
| c. Import to U.S. | -65.0 | — | — |
| d. Capital Transfer | -135.0 | — | — |
| e. Foreign Income From Servicing the Would-Be Exported Aircraft in the U.S. ^{s/} | -37.0 | +37.0 | — |
| f. Total Balance of Payments, including Capital Transfer | -45.4 | +774.0 | — |
| g. Total Balance of Payments, excluding Capital Transfer | 89.6 | +774.0 | 0.12 |

TABLE 18. ILLUSTRATIVE CALCULATIONS OF THE IMPLICATIONS OF
EXPORT OF TECHNOLOGY IN A "NAKED" FORM--Continued

Notes to Part II:

- a/ See U.S. Department of Commerce, Bureau of Economic Analysis, Special Survey of U.S. Multinational Companies, 1970, BEA - SUP 72-03, Table 3, p. 23.
- b/ \$630 million of sales in country N plus \$132 million of exports to neighboring (third) countries plus \$65 million of exports to the United States.
- c/ \$625 million of would-be exports to country N plus \$112 million of exports to third countries (85 percent of \$132 million) plus \$55 million of production of import substitutes (85 percent of \$65 million).
- d/ 4 percent of \$715 million--the value produced in country N based on protected U.S. know-how (about the average fee for such transfers of know-how).
- e/ 57 percent of item (2a)--same percentage as U.S. multinational companies received in 1970.
- f/ 4.2 percent of net sales (item 1).
- g/ 3.0 percent of \$792 million.
- h/ 13.5 percent of total net sales, assumed to be avionics and impractical for the companies to produce abroad.
- i/ \$625 million of would-be exports to country N plus \$112 million of exports to third countries.
- j/ 7.9 percent of total sales, as did the sample of 298 multinational companies in 1970.
- k/ 11.2 percent of 60 thousand jobs (per \$1 billion of net sales).
- l/ 79.2 percent of 60 thousand jobs.
- m/ 6.7 thousand jobs times \$12,500 per year.
- n/ 47.5 thousand job times \$12,500.
- o/ 48 percent of \$44.9 million (sum of item 2a and 2b) plus 4 percent of \$34.7 million (item 2c) plus 10 percent of \$83.8 million (item 6).
- p/ 48 percent of \$23.7 million (item 2d) plus 10 percent of \$593.8 million (item 6).
- q/ Assumed that the production would be spread over 5 years (\$165 million per year) and that for each dollar of annual sales the subsidiary would need 82 cents of capital assets, as did the sample of 298 multinational companies in 1970.
- r/ Assumed that all income was repatriated. In 1970 only 55 percent of net income of U.S. foreign manufacturing affiliates was repatriated.
- s/ Assumed to amount, at a minimum, to 5 percent of the value of would-be exports from the United States.

Chart 3. U.S. Manufacturing Companies' Receipts from and Payments to Foreign Countries for Technological Royalties and License Fees
(\$ Millions)



Source: Table 19

technology ("relevant sales") that are produced abroad⁵⁰ and that they most probably understate the true volume of the exports in question

⁵⁰The figure of about 4 percent is an average based on unpublished data of 141 large U.S. companies on their charges to subsidiaries in Europe for technology transfers from the United States as percent of "relevant sales." This information was furnished to the U.S. Department of Commerce in 1967 in the context of a survey on "Experiences and Practices of U.S. Corporations in Western Europe" (Bureau of the Budget Form No. 41-567036). The charges of individual companies reporting to this survey ranged from a fraction of one percent to as much as 10 percent, depending on such factors as type of product, the scale of production of relevant item, cost of development of technical information, cost of supply of the technical information to the licensee, profitability or cost savings of the licensee, needed technical support to fully exploit the know-how, relative degree of advancement of competitive foreign technology, exclusiveness of the licensee's rights, how long the license agreement was supposed to be in force, and the degree of competition with technology of other U.S. and foreign companies.

Both this average and the range would seem to be in line with world-wide practices. In the relevant records of the U.S. Court of Claims, handling suits of U.S. citizens against the U.S. Government for the infringement of their patent rights, for example, I found about half a dozen recent money judgments, ordering the U.S. Government to pay to the suing patent holders fees ranging from 2 to 5 percent of the relevant purchases (sales). In 1966, a Japanese source published data to the effect that the Japanese industry's fees for the technological licenses (class "A") obtained from U.S. companies in 1960-1965 averaged 4.1 percent of relevant sales, and for licenses obtained from other countries, mostly European, 4.2 percent (cf., Foreign Investments in Japan, Tokyo, Heavy and Chemical Industries News Agency, 1966, pp. 39-344). In February 1967 the journal Atlas, reporting after Die Zeit of Hamburg, West Germany, carried a news item to the effect that the Soviet Government was offering to sell some 300 technological licenses to Western firms asking a certain flat payment in advance of the exploitation of the know-how and "running" royalties ranging from 4 to 10 percent of relevant sales. The specific "running" rate asked is said to have depended on the Soviet cost of developing the know-how, the degree of advance of the know-how over the preceding technology, and the economic importance of the know-how.

because many U.S. companies transfer technology in exchange for equity participation in foreign companies, but the value of these equity rights is not included in the estimates of the companies' receipts. But even with this understatement the estimates imply that, e.g., by 1970 the value of the manufactured products produced abroad on the basis of this technology amounted at a minimum to some \$27 billion (= \$1,097 million + 0.04) or almost as much as the value of total exports of manufactured products from the United States in that year. I label this a minimum estimate (\$27 billion) because it only refers to the value of products based strictly on the protected know-how for which the companies received royalties and license fees. Associated sales, that is, sales of products to which the protected know-how imparts essential characteristics, might have amounted to 3 times as much because the protected know-how usually covers only part of a product though it is essential to the economic and technical characteristics of the whole product.⁵¹ The data in Table 19 also imply that U.S. companies have been exporting manufacturing technology in a "naked" form at a much faster rate than they generate new innovations

⁵¹In numerically controlled (N/C) machine tools, for example, patents might cover only the controls, the value of which usually amounts to about one-third of the total installation, but these controls are essential for the economic and technical characteristics of the entire installation (machine tool).

TABLE 19. U.S. COMPANIES' APPROXIMATE RECEIPTS FROM AND PAYMENTS TO FOREIGN COUNTRIES FOR TECHNOLOGICAL ROYALTIES AND LICENSE FEES, SELECTED YEARS 1960-1970, \$ MILLIONS

| Industry and Item | 1960 | 1965 | 1970 | Average Annual Growth Rate, % Per Year |
|--|------|------|-------|--|
| <u>Manufacturing Industry</u> | | | | |
| Receipts | 275 | 525 | 1,097 | 14.8 |
| Payments | 38 | 71 | 132 | 13.3 |
| Balance | 237 | 454 | 965 | --- |
| Ratio of Receipts to Payments | 7.2 | 7.4 | 8.3 | --- |
| <u>Industries Other than Manufacturing</u> | | | | |
| Receipts | 89 | 141 | 273 | 11.8 |
| Payments | 12 | 20 | 41 | 13.1 |
| Balance | 77 | 121 | 232 | --- |
| Ratio of Receipts to Payments | 7.4 | 7.1 | 6.7 | --- |

Sources:

The figures represent estimates based on U.S. Department of Commerce, Bureau of Economic Analysis' data used in estimating U.S. balance of payments regarding U.S. receipts and payments of "royalties and fees" from and to foreign countries, and reflecting both, cash transactions between parent companies and foreign subsidiaries and transactions between independent companies. BEA's data refer to royalties and license fees for "transfers of technology," royalties on printed matter (but not on movie films, TV tapes, etc.), rentals on leased equipment (but not movie films and TV tapes), and "management fees." Compared to BEA's data the estimates posted in the Table exclude "management fees" and thus represent rough approximations of U.S. receipts and payments for "transfers of technological know-how." The bulk of the excluded "management fees," whether in receipts or payments, consist of the pro-rata shares of overhead cost which the parent companies charge their subsidiaries operating in foreign countries and have nothing to do with "transfers of technology" or "technological know-how" nor with the so-called "technological balance of payments." However, the estimates (in the Table) are short of "pure" receipts and payments strictly for "transfers of technology" in that they still include some royalties on "printed matter" and some "rental fees." These "undesired" inclusions, however, are believed to be small since BEA's sample of companies, on which its aggregates are based, permits only sporadic inclusion of royalties on "printed matter" and the equipment rentals in international transactions are rather rare and financially insignificant.

The estimates do not include the values of the exchanges of technology between U.S. and foreign companies nor the values of U.S. companies' export of technology in exchange for equity participation in foreign companies.

(the latter implicit in growth rates in their expenditures on R & D in Table 14) and almost twice as fast as the growth of exports of U.S. manufactured goods.

U.S. imports of foreign manufacturing technology for which U.S. companies paid royalties, and/or other fees, were only a trifling fraction of exports in 1960, and even smaller in 1970.

Throughout the time period covered in Table 19, the incidence of the technology exports has been spread fairly widely over most U.S. industries, but the heaviest concentration (some 80 percent or so) was in what I define as technology-intensive industries. Statistical data crudely bearing on the actual experience of major European countries, Japan and the United States with respect to the relative use of foreign technological know-how in a "naked" form versus domestic growth in output and export of technology-intensive products are shown in Table 20. The only major U.S. industry in the category of technology-intensive industries that has not done much of this exporting so far is the aerospace industry and this is the industry which throughout the post World War II period has been responsible for the largest U.S. trade surpluses of manufactured goods of any single industry. By now, according to numerous press reports and speeches of key industry people, however, even this industry seems to be set to do the same thing.⁵²

⁵²See, e.g., Forbes, May 15, 1973, p. 24; Aviation Week and Space Technology, May 28, 1973, pp. 27-28; Aviation Daily, May 16, 1973, p. 94 and June 5, 1973, p. 194; and Boeing News, May 17, 1973, p. 1.

TABLE 20. DATA BEARING ON COMPARATIVE EXPERIENCES IN RELATIVE USE OF FOREIGN TECHNOLOGICAL KNOW-HOW IN A "NAKED" FORM VERSUS DOMESTIC GROWTH IN OUTPUT AND EXPORT OF TECHNOLOGY-INTENSIVE PRODUCTS: SELECTED COUNTRIES

| Country | Ratio of Payments for Licenses, Patents, etc. to Receipts | | Average Annual Rate of Growth in Domestic Output of Technology-Intensive Products in 1955-1967 | Gains in the Share of World Exports ^{a/} of Technology-Intensive Products Between 1954 and 1970, Percentage Points | | |
|----------------|---|-------|--|---|------|------|
| | 1963-1965 | 1968 | | Net Change | From | To |
| West Germany | 2.43 | 2.39 | 7.7 | +3.4 | 17.6 | 21.0 |
| Italy | 4.17 | 3.36 | 10.1 | +3.6 | 2.4 | 6.0 |
| France | 2.53 | 2.32 | 5.1 | +1.4 | 6.4 | 7.8 |
| Japan | 22.00 | 10.00 | 19.7 | +7.9 | 1.8 | 9.7 |
| United Kingdom | 1.05 | 0.84 | 3.7 | -8.7 | 19.0 | 10.3 |
| United States | 0.14 | 0.15 | 4.9 | -12.5 | 35.5 | 23.0 |

a/ Exports of 14 industrialized countries

Sources:

Payments and receipts for licenses, etc.: OECD, Gaps in Technology Between Member Countries, Analytical Report, Paris, 1970; _____, "Invisibles in the 1960's," Economic Outlook, July 1970, p. 15; and U.S. Department of Commerce, Bureau of Economic Analysis (see source note in Table 19).

Growth rate of output of technology-intensive products: OECD, The Engineering Industries, selected years, and OECD, The Chemical Industry, selected years.

Gains in market share of technology-intensive products: U.S. Department of Commerce, Market Share Reports; and U.N., Commodity Trade Statistics.

Calculations analogous to those presented in Table 18 but based on the U.S. companies' aggregate receipts and payments for the transfers of manufacturing technology (Table 19), the approximate ratio of those receipts and payments to the relevant value of sales (4 to 5 percent), the differences between the overall U.S. and foreign cost and price levels of manufactured goods (Tables 7 and 8), an at least theoretically appropriate range of foreign price-demand elasticities for products embodying market-tested new technology (0.1 to 0.9),⁵³ and the apparent aggregate U.S. exports and imports of products related one way or another to these transfers imply that had the United States done nothing more than it did in promoting new technology in the United States, but did not engage into the kind of export of technology in question as it did, the kind of deterioration of U.S. trade and balance of payments as we have been witnessing since 1971 might have come, but many many years later rather than in 1971.

⁵³The most "respectable" estimate of foreign price-demand elasticity for all U.S. exports, based on price data rather than "unit values" that I know of, is 0.5. If this estimate is reasonably accurate then the foreign price-demand elasticity for U.S. products embodying market-tested new technology alone must be appreciably lower than 0.5. The statement of a "theoretically appropriate" range between 0.1 and 0.9 is equivalent to the assumption that the elasticity for the products in question is merely inelastic in the conventional sense of the term, that is, the numerical value of the coefficient is smaller than unity.

In Lieu of A Summary: A Few Historical Quotations on Changes in America's Attitude Toward Technology and Trade

● Shortly before, during and for a short time after the American Revolution there was considerable debate among the "founding fathers" as to what type of character the U.S. economy should have. Thomas Jefferson favored an economy of landowners, principally engaged in farming. Many Federalists, under the leadership of Alexander Hamilton, favored an industrial economy. Hamilton's view prevailed and the U.S. embarked on a process of industrialization following Hamilton's strategy the essence of which was: promoting the immigration of manpower, in general, and technologically-skilled manpower, in particular; promoting capital infow from abroad; and protection of "infant" industries.⁵⁴

In response to the U.S. strive for industrialization, Great Britain forbade the emigration of trained artisans and workmen in 1765, in 1772 and 1785; prohibited the exportation of any tool, machine or plans thereof in 1774; and in 1781 placed an export embargo on all utensils

⁵⁴Of the three elements of Hamiltonian strategy, economic historians usually emphasize the protection of "infant" industries. His Report on the Subject of Manufactures, submitted to Congress on December 5, 1791, in his capacity as Secretary of the Treasury, does not emphasize it any more than the other two. In fact all three would seem to have been to him equal and indispensable elements of overall policy. (Cf., Alexander Hamilton, Report on Manufactures, Boston: A reprint by the Home Market Club, 1892).

that might be used in manufacturing. In 1785 even British coal miners were forbidden to leave the country.⁵⁵

In its effort to overcome its technological dependence on Great Britain, America was considerably helped by France. France's rationale for doing this was eloquently described in E.I. Dupont's letter, written in America, to his father in France.⁵⁶

"The greatest harm that can be done to the English is to destroy their trade; the only way to accomplish that in this country is to establish manufactures that will rival theirs. The French manufacturers will never be able to overcome American prejudice and habit and it is only by American industries that England can be fought. This truth was felt in France before my journey in 1801 and secured for me all the help that I found there."

In 1972, another Frenchman, Jean-Jacques Servan-Schreiber, in an interview with Business Week, commented on related matter in the following words:⁵⁷

"America has to face the fact that there is a new world for them. American companies outside the U.S. are competing with the U.S.-based part of the business. IBM France, for example, is competing with IBM America. If there were no IBM France, we would import American computers."

⁵⁵Cf., Edward Frank Huphrey, An Economic History of the United States, New York: The Century Co., 1931, p. 155.

⁵⁶Quoted by Norman B. Wilkinson in "Brandywine Borrowings from European Technology," Technology and Culture, Vol. IV, No. 1, Winter 1963, p. 8.

⁵⁷Business Week, October 14, 1972, p. 66.

- With the limited manpower and capital resources, the only way America could progress rapidly was technology and technological prowess became the preoccupation of practically the entire nation. As early as 1835, still other Frenchman, Alexis de Tocqueville, commented on this as follows:⁵⁸

"I accosted an American sailor and inquired why the ships of his country are built so as to last for only a short time; he answers without hesitation that the art of navigation is every day making such rapid progress that the finest vessel would become almost useless if it lasted beyond a few years. In these words, which fell accidentally, and on a particular subject, from an uninstructed man, I recognize the systematic idea upon which a great people direct all their concerns."

In 1971 the Gallup Organization, commissioned by Newsweek, conducted a poll of college students' thinking about various problems facing America. 41.8 percent of the interviewed students said that there was too much emphasis on science and technology.⁵⁹

- Because of rapid technological progress, by the turn of the 20th century America emerged as the strongest trading nation in the world. In

⁵⁸Alex de Tocqueville, Democracy in America, Vol. II, p. 39.

⁵⁹See Newsweek, February 22, 1971, p. 61

1901, Fred A. McKenzie, a British journalist and politician, but born in Canada, described this emergence in following terms:⁶⁰

"Today . . . Americans are selling their cottons in Manchester, pig iron in Lancashire and steel in Sheffield. They send oatmeal to Scotland, potatoes to Ireland and our national beef to England. It only remains for them to take coals to Newcastle."

. . . "The most serious aspect of the American industrial invasion lies in the fact that these incomers have acquired control of almost every new industry created during the past fifteen years."

Regarding the "control" of new industries, he referred to the telephone, phonograph, electric streetcar, automobile, typewriter, passenger elevator, machine tools, carpet sweeper and Mr. Eastman's portable camera where "you press the button, and we do the rest."⁷

In 1969, a Japanese team composed of scholars and industrialists, under the auspices of the Japan Techno-Economics Society, conducted a factfinding tour of the United States aimed at collecting information for Japan's long-range plans of technological and industrial development. Upon return the team reported:⁶¹

⁶⁰Fred A. McKenzie, The American Invaders: Their Plans, Tactics and Progress, Street and Smith, 1901, pp. 157, \$0.25.

⁶¹The Oriental Economist, July 1970, p. 68.

"The United States cannot necessarily be Japan's target leader. We are now in an age in which we have to forecast and plan Japan's future industrial development independently."

And on April 8, 1973, the columnists Rowland Evans and Robert Novak wrote from Tokyo:⁶²

"The American businessman, once 10 feet high in Japanese eyes, is now viewed here as a midget . . . Except for a short, exotic list (computers, beef, jet fighters, nuclear power plants, etc.), Japanese businessmen feel they can outsell the Americans here and abroad with better products. So, one reacts to American import possibilities this way: 'If Americans prefer the Toyota to the Pinto, why shouldn't the Japanese?'"

⁶²Washington Post, April 8, 1973.

IV. POLICY ISSUES

Probable Consequences for the United States if the Current Trends in Technology Continue

There is a substantial number of people in the United States who are either unconcerned about the trends as portrayed in the two preceding sections, and there are some who welcome them.

As far as I could determine the rationale for the lack of concern would seem to be at least twofold (defined, of course, in a "class-type" manner rather than in terms of what an individual actually says). In most general terms, many of the unconcerned people seem to believe that the international disparities in the rate of technological advance are largely a function of the relative level of technological development which various countries have achieved so far and the higher the stage of development the more difficult it is to advance. To those holding this view, the countries whose technology is currently advancing faster than that of the United States are doing so because their stage of technological development is still at a much lower level than that of the United States, but when they achieve the same level as that of the United States, they will face the same problems as the United States does and their further development will slow down. Hence, there is no need for concern. Others rationalize their lack of concern by believing that technology is the source of material well-being of society only and that in material well-being the United States at large is reaching the "upper limit" or at least is as affluent as it needs to be. Pushing for more material well-being, implicit in fostering productivity and

international competitiveness of domestic industry, according to these people, is silly. What the United States needs, they seem to argue, is a more "equitable" income distribution and a better quality of life--pollution-free, crime-free, etc.--on the domestic front; and more capitalization of our "mature economy" advantage, via the export of capital and technology rather than the export of goods, on the foreign front.

To people who welcome the trend the sole rationale would seem to be the quality of the physical environment. To most of these people, any further advance in technology means a further deterioration of the physical environment and the slowdown in rate of further technological advance apparent in the trends is a welcome slowdown in the rate of the deterioration of the physical environment.

A reasonably comprehensive assessment of the merits of these three views would take a lengthy and highly philosophical treatise which, obviously, cannot be undertaken in this paper. Inasmuch as the merit of most of what I am going to say in the remaining portion of this paper depends in some measure on the tenability of these propositions, I must comment at least on the key points.

Regarding the advantages and constraints of various stages of technological development I, of course, agree with the proposition that in the environment of a reasonably free flow of technological know-how across international borders countries at a lower level of development find it easier to progress than the countries at a higher stage of development. However, this is most probably so not so much because it is much easier to make a progress, say--by one percentage point, when,

other things being equal, you are relatively "fresh" in the business than if you are in an advanced stage of the same business (though many economists, reasoning along the lines of the theories of all kinds of "diminishing returns," believe this to be the true), but largely because low-development countries have the opportunity to import advanced technology from abroad faster and at a price usually cheaper than if they tried to develop the know-how themselves. As I demonstrated in the preceding section, however, most of the other countries, and which the people advancing the proposition have in mind, have progressed faster than the United States not only because of their importing technology from the United States, but also because of the much greater intensity of their effort, chiefly the investment in R & D relevant to economic development and investments in new plant and equipment. From this it follows that though the rate of these countries' progress relative to that of the United States might diminish once they reach parity in the level of the technological development with the United States, because of the fall-off of the advantages of importing technology from the United States, there is no valid a priori reason to believe that they will not continue to exert a greater effort for further progress than the United States and, because of this, they will not surpass the U.S. level of development.

Nor is there any valid reason to believe that on the road to parity with the United States they will necessarily generate the same problems that currently plague the United States, such as pollution, crime, etc. Whether they will generate the same problems or not will depend on what

they will do with the benefits from progress. Chances are that they will become increasingly concerned about these matters and with more rapidly growing real incomes they would find it easier to cope with the problems in question than the United States could with the slower growth of incomes.

Moreover, the principal issue at hand is not what might happen after other countries achieve technological parity with the United States, but what will be the consequences for the United States on the road to this parity.

Regarding the second rationale for the lack of concern about the trends, that is, the belief that in material well-being the United States is by now reaching the "upper limit" or at least is as affluent as it needs to be and that from now on it should concentrate on the "quality of life" via the redistribution of income, etc. on the domestic front, and on the export of capital and technology rather than the export of domestically produced goods on the international front, there might be some merit only in the proposition that the United States at large might benefit from better income distribution than it presently has. Taking this philosophy as a whole, however, it is sheer anopia.

As to the "upper limit" of our advance, there might be something of that sort in store for us (and everybody else) in the future, but as of now this limit is not yet in sight. The data in Table 21, for example, indicate that even in manufacturing, where a large portion of the last hundred years' total technological and productivity progress was

TABLE 21. DATA BEARING ON CURRENT DISPARITIES IN THE LEVEL OF PRODUCTIVITY
IN SELECTED U.S. MANUFACTURING INDUSTRIES: 1958, 1963 AND 1967

| SIC code | Industry | Ratio of value-added per employee in 25 percent highest productivity establishments (plants) to the average of the respective industry | | | Ratio of value-added per employee in 25 percent highest productivity establishments to the value- added per employee in 25 percent worst performing establishments | | |
|-------------|--|---|------|------|--|------|------|
| | | 1958 | 1963 | 1967 | 1958 | 1963 | 1967 |
| 2211 | Broad woven fabric mills, cotton. | 1.6 | 1.6 | 1.4 | 2.8 | 2.0 | 1.9 |
| 2621 | Paper mills, except building paper mills..... | 1.6 | 1.5 | 1.4 | 2.4 | 2.2 | 2.2 |
| 2812 | Alkalies and chlorine..... | (NA) | 2.3 | 2.3 | (NA) | 3.7 | 3.2 |
| 2815 | Intermediate coal tar products... | 1.8 | 1.5 | 1.7 | 2.7 | 2.8 | 2.9 |
| 2821 | Plastics materials and resins.... | 1.9 | 1.8 | 1.8 | 3.2 | 3.1 | 3.6 |
| 2911 | Petroleum refining..... | 2.2 | 1.4 | 1.5 | 7.8 | 3.2 | 4.8 |
| 3211 | Flat glass..... | 1.2 | 1.4 | 1.2 | 1.5 | 1.9 | 2.4 |
| 3312 | Blast furnaces and steel mills... | 1.7 | 1.6 | 1.5 | 2.2 | 2.3 | 2.3 |
| 3323 | Steel foundries..... | 1.3 | 1.3 | 1.5 | 1.5 | 1.6 | 1.8 |
| 3334 | Primary products of aluminum..... | 1.3 | 1.1 | 1.1 | 1.9 | 1.7 | 1.7 |
| 3391 | Iron & steel forgings..... | 1.7 | 1.7 | 1.4 | 1.8 | 2.0 | 1.9 |
| 3461 | Metal stampings..... | 1.5 | 1.3 | 1.3 | 1.9 | 1.5 | 1.7 |
| 3519 | Internal combustion engines, n.e.c..... | 1.3 | 1.4 | 1.6 | 1.7 | 2.0 | 2.3 |
| 3522 | Farm machinery and equipment..... | 1.7 | 1.5 | 1.4 | 2.4 | 2.1 | 2.1 |
| 3541 | Machine tools, metal cutting..... | 1.6 | 1.5 | 1.3 | 1.8 | 1.9 | 1.9 |
| 3561 | Pumps and compressors..... | 1.7 | 1.7 | 1.6 | 1.9 | 2.1 | 2.1 |
| 3621 | Motors and generators..... | 1.5 | 1.4 | 1.4 | 2.0 | 1.5 | 1.8 |
| 3632 | Household refrigerators and freezers..... | 1.1 | 1.0 | 1.4 | 2.1 | 2.4 | 1.6 |
| 3717 | Motor vehicles and parts..... | 1.8 | 1.6 | 1.4 | 2.5 | 2.8 | 2.5 |
| 3722 | Aircraft engines & parts..... | 1.3 | 1.2 | 1.4 | 1.5 | 1.2 | 1.8 |
| | Average..... | 1.6 | 1.5 | 1.5 | 2.2 | 2.2 | 2.4 |

NA Not available.

Source:

NOT REPRODUCIBLE

Based on special tabulations of census schedules in regular census years by the
Department of Commerce, Bureau of the Census.

concentrated, the potentiality for continued productivity growth amounts to a minimum of 50 percent of the current level. Achieving this would merely require that the industries' average advance to the level already achieved by their 25 percent or so best performing plants. And if these industry averages advanced to levels already achieved by the very best plants in each industry, the average growth would probably amount to 100 percent or more. At least conceptually, all of this should be possible by the fuller use of technology and organizational innovations already at hand. There is no question that further improvements in both would permit even greater progress. There is no indication that people now working in the more productive plants work any harder, in a physical sense, or are exposed to more "dehumanizing" conditions of work than people working in the worst-performing plants. If anything, it is probably the other way around.

Instead of fostering an increased exploitation of these potentialities, what the people in question propose for the United States is in effect that the United States embarks on the post World-War II British-type of experiment the essence of which was an attempt to become more "well-to-do" by "reslicing the pie" rather than making the pie progressively larger; and "to live" on investment income from abroad rather than on proceeds from the exportation of goods. As we all know, the result of this experiment, in both respects, has been dismal. There is no reason to believe that in undertaking this type of experiment the United States would get better results than the British. If anything, it is likely that the United States would get worse results

because, on the domestic front, the United States is a much less homogeneous society and, therefore, would find it harder to manage this type of experiment; and, on international front, the United States would have to work in a much less favorable environment than Britain had (the British have tried to live on investment income largely from within their empire, whereas we would have to depend on income from totally independent and frequently not so friendly countries. Recent experiences of U.S. companies in Chile, Peru, Libya, and even in Canada, are reminders of this reality).

Regarding the environmentalists' argument, finally, it should suffice to note merely that technology per se is not the thing that damages the environment, but the people who indiscriminately use the less than optimum (from society's point of view) technology and that it is practically unthinkable that we could correct "past mistakes" without an adequate flow of new know-how aimed at both, technical solutions of the existing environmental problems and providing new economic means to pay for the job.

Careful analysis of the information at hand points to rather dismal consequences for the United States if the trends in question were to continue, and this on both the international as well as domestic fronts.

On the international front there most certainly would be a further decline in the competitiveness of domestic manufacturing industry with the result of continued large deficits in the balances of trade, further decline in "meaningful" (market-demand-induced) employment opportunities,

continued large deficits in the balance of payments, and continued downward pressure on the external value of the dollar.

Regarding the extent to which the external value of the dollar might be reduced as a result of these pressures, one should bear in mind the fact that, as I showed in Section II, Table 8, the devaluation of the dollar from December 1971 through the middle of 1973 and effectively amounting to about 16.4 percent (U.S.-import-weighted average) reduced the manufacturing cost advantage of all other countries in the world vis-a-vis the United States of some 26 percent only by six percentage points, from about 74 percent to about 80 percent of the U.S. level. With this residual cost disadvantage, plus continued weakening of the technological competitiveness of U.S. domestic manufacturing industry, plus the country's apparently low long-term elasticity of supply of agricultural products and some other raw materials (Table 10), plus mounting imports of oil and numerous other minerals of inadequate domestic supply, plus the overhang of 80 to 100 billion of dollars already abroad, there is practically no limit how far the dollar's external value might go further down. In the given set of circumstances, the only thing that could prevent this from happening is clearly the regaining of U.S. technological advantage in manufactured goods. Without any backing by the technological advantage of the domestic industry, the dollar's external value relative to its domestic purchasing power might become not much different than was the situation with, for example, the Japanese yen in the 1950's and early 1960's, that is, the time when Japan's technological advantage vis-a-vis

the rest of the industrialized world was hardly "worth a dime." At that time, the yen's external value was lower than its domestic purchasing power by some 35 to 40 percent.

To people who consider the dollar's exchange rates with other currencies as mere accounting ratios any further depreciation of its external value might be of no or little significance, but for the society as a whole it would mean paying progressively increasing amounts of sweat for the imports without which the economy cannot properly function (such as oil) or even for imports which are high on the individual consumers' preference lists. Domestically the society can usually go on piling public debt as long as the Government budgets can pay interest and other service charges associated with this debt, but international public debts, including those arising out of balance of payments deficits, must ordinarily be paid with public sweat, and usually with progressively larger and larger amounts of sweat.

The international consequences outlined above, that is, continued deterioration in U.S. trade and balance of payments, and the resultant downward sliding of the external value of the dollar, might produce the kind of protectionist sentiment in the country that the Government might not be able to control. And all of this might have rather drastic implications for the U.S. leadership position in the world in which the country has invested so much blood and sweat since the beginning of World War II.

On strictly the domestic front, the continued lag in productivity growth coupled with continued "rise in expectations," which neither the

Government nor any other public institution, including the church, have learned to control, would be tantamount to continued inflationary pressures, pressures for the redistribution of income ("reslicing of the pie"), and lag in improvement or even a decline in the present level of the "quality of life."

The Government's Posture

The trends in U.S. civilian technology as sketched above have been under debate and study within the Government since early 1969. Regarding the studies I refer primarily to my own work at the Department of Commerce;⁶³ deliberations of the Panel on Science and Technology Policy of the President's Science Advisory Council in 1970-1971, appointed by Dr. Lee DuBridge and chaired by Patrick E. Haggerty of Texas Instruments;⁶⁴ Hearings by the House Subcommittee on Science Research

⁶³Michael Boretsky with the assistance of Robert McKibben, U.S. Trade Prospects and Policy Needs (An Advance Communication), September 1969 (Prepared for Secretary Maurice H. Stans, Unpublished); - Trends in U.S. Trade and the International Competitiveness of U.S. Industry, December 1969 (Unpublished),--"Concerns About the Present American Position in International Trade," Proceedings of the National Academy of Engineering symposium Technology and International Trade, October 14-15, 1970, pp. 18-65; and--U.S. Merchandise Trade: Trends and Policy Options, March 1971 (Prepared for Secretary Maurice H. Stans and Peter G. Peterson, then Executive Director of the Council on International Economic Policy--Unpublished).

⁶⁴The proceedings of the Panel, including extracts of the background material, have been compiled in 9 volumes by the Texas Instruments Information Center. The final report of the Panel, submitted to Dr. Edward E. David, then Science Adviser to the President, in September 1971, has not been published.

and Development in 1970, chaired by former Congressman Emilio Q. Daddario of Connecticut;⁶⁵ a series of hearings on science, technology and the economy conducted by the House Subcommittee on Science, Research and Development, chaired by Congressman John W. Davis of Georgia in 1971 and 1972;⁶⁶ and the White House's assessment of "technological opportunities" from September 1971 to March 1972 headed by William M. Magruder. Of considerable importance was also the National Academy of Engineering symposium on technology and international trade held in October 1970.⁶⁷

The degree to which understanding of the issue and the concern about the trends had advanced with some members of the President's cabinet by the middle of 1971, that is, shortly before institution of the New Economic Policy, might be judged by a passage from Secretary Maurice H. Stans' testimony before the aforementioned House Subcommittee on July 27, 1971:

⁶⁵Cf., The Subcommittee's Report No. 23 (Hearings during July, August and September 1970).

⁶⁶Cf., The Subcommittee's Report No. 7 (Hearings on July 27-29, 1971); Interim Report, Serial 0, February 1972; and Report No. 23 (Hearings on April 11-13, 18 and 20, 1972).

⁶⁷The proceedings of the National Academy of Engineering symposium, Technology and International Trade, Washington, D.C., 1971.

"The magnitude of the problem is such that we cannot rely upon normal market forces to maintain our advantage in technology. We are at the forefront in many technological areas. The costs of breaking new ground in some of these areas are high--higher than private companies or perhaps consortia are able to justify because the risks are so great. We have recognized this fact in the space, defense, and atomic energy areas. Other trading nations have recognized it in the area of civilian R & D and have taken steps to assist technological development. If we are to maintain our advantages in this area we must first of all accept the idea that it has become a proper sphere for governmental action."

The President has addressed himself to the issue "in a big way" on three occasions:

- (1) In his speech announcing the New Economic Policy on August 15, 1971;
- (2) In his address to a joint session of Congress on September 9, 1971; and
- (3) In his special message to Congress on matters of science and technology of March 16, 1972.

In the first two statements, the President saw the need to enhance technology primarily as a tool for enhancing productivity growth, enhancing the competitiveness of U.S. industry in foreign and domestic markets, and, most important of all, the creation of jobs; and the policy that he thought of using at the time for the purpose--tax stimulants for R & D. The August 15 statement was brief, but could hardly have been more eloquent:

"Looking to the future, I have directed the Secretary of the Treasury to recommend to the Congress in January new tax proposals for stimulating research and development of new industries and new technologies to help provide the 20 million new jobs that America needs for the young people who will be coming into the job market in the next decade."

The September 9 statement greatly amplified that of August 15 and explained the significance of the intended policy change:

"Achieving these goals will be in the vital interest of the United States not just for the next year, not just for the next 10 years, but for the balance of this century, and beyond. I look forward to working with the Congress and getting the best thinking of the Congress in preparing for this great experiment . . ."

The primary policy promulgated in the March 16, 1972 message, however, was the acceleration of the development of technology for "quality of life" improvements already underway--mass transit, protection from natural disasters, control of drugs and health care--and energy research. For this purpose the budget for Fiscal Year 1973 requested an additional \$358 million, from about \$999 in Fiscal Year 1973 to \$1,357 million in Fiscal Year 1973. The message also initiated a small Experimental Technology Incentives Program to be administered

by the National Science Foundation and Commerce's National Bureau of Standards.⁶⁸ The idea of a serious technology enhancement program aimed at enhancement of productivity growth and of international competitiveness of U.S. industry (and, hence, creation of job opportunities via new products and industries), the goals of primary concern in the August 15 and September 9, 1971 statements, was dropped, apparently because of budgetary constraints and the lack of a sensible proposal how to go about it. The President implied both in the March 16 message when he said:

" . . . We must define our goals clearly, so that we know where we are going. And then we must develop careful strategies for pursuing these goals, strategies which bring together the Federal Government, the private sector, the universities, and the States and local communities in a cooperative pursuit of progress. Only then can we be confident that our public and private resources for science and technology will be spent as effectively as possible."

⁶⁸For Fiscal Year 1973 Congress appropriated for this program about \$29 million, Office of Management and Budget "apportioned" \$22.2 million, and the two agencies actually spent or obligated \$14.5 million. For Fiscal Year 1974 the Administration's budget requested \$26.8 million, and the Congress is likely to appropriate about \$17 million.

Policy Needs

The preceding discussion might have made it appear that the only thing that the United States needs to cope with the trends in question is more R & D. As far as I am concerned, this is not so. More economically and "quality-of-life" oriented R & D is an important element of U.S. needs, but it is far from everything. In my judgment, what the United States needs (please note I am addressing myself here to the needs, not options) is a comprehensive national technological policy. In broad terms I define such a policy simply as the sum of deliberate actions on the part of Government aimed at the increase and improvement of technological options and alternatives for all productive units in the economy for the furtherance of national objectives within the constraints of available and/or accessible resources.

At this time there are bits and/or pieces that might fall into the scope of this definition, but the country does not have a coherent policy per se. As I see it, the institution of such a coherent policy, in the conditions of the kind of market economy and Governmental institutions as we have today, would have to have a dozen or so strategic elements. These would have to include:

(1) Intelligent planning and continuous review of the country's level of effort in the enhancement of technological development by major processes and sectors of the economy. By "intelligent planning" I mean essentially the same kind of planning that the late Gerhard Colm, Chief economist of the National Planning Association for many years, described as concerted planning, and defined as a procedure in which

the benefits of coordination of purpose and activity are combined with the individual freedom of choice and without stifling centralized controls.⁶⁹ At this time we have nothing of this sort, nor, as I demonstrated in this paper, do we know where we are heading.

(2) Development and institution of policy measures assuring an optimum supply of appropriately trained scientific and technological manpower, both as to various educational levels and within each level (including supply of technicians and "craftsmen"), consistent with the country's prospective (long-term) level of effort in technological development. We have virtually nothing of this sort and how damaging this has been to the country's interest might best be seen in our implementation of President Kennedy's decision to "go to the moon." The goal, including the deadline, was decided upon in terms of an R & D budget without much, if any, regard to the availability of S & T manpower. To obtain the necessary manpower, NASA and its contractors were forced to compete with the alternative employers of S & T manpower, notably the civilian-market-oriented technological endeavors of industry as well as the pure defense segment of the "military-industrial-complex." In the process

⁶⁹Cf., Gerhard Colm, "The Next Step: Concerted Planning," State and Local Government Planning Proceedings, 9th Annual Conference of the Center for Economic Projections, National Planning Association, October 24, 1968, Report 69-J-1. I owe this reference to Nestor Terleckyj.

of this competition, salaries of scientists and engineers skyrocketed and this increased not only the cost of "going to the moon," but it also significantly hurt the operations of other segments of industry as well as the overall rate of the "bread-and-butter" advance of the civilian economy. Equally damaging to the economy might also prove to be the lack of offsetting measures which would counter the reduction of the enrollment in the S & T colleges and universities induced by recent cuts in NASA's and DoD's R & D budgets. This reduction, if permitted to persist for a few more years, would severely damage the technological viability of the country for the decades to come.

(3) Development and institution of general and meaningful (effective) incentives for an optimum level of private investment in R & D. At this time we have no such incentives and, to my knowledge, there is formidable opposition toward the institution of such incentives. The institution of such incentives, however, is called for by both pragmatic and theoretical considerations. From a pragmatic point of view, the need for such incentives arises from the fact that the flow of technological innovations in the United States generated by market forces alone has been inadequate for quite some time and, being technologically the most advanced country in the world, the United States simply does not have any other way to assure a substantially better stream of such innovations and, hence, an adequate long-term rate of progress, except through fostering its own R & D effort by means of Governmental incentives (unlike other countries which, being generally at a lower level of technological development, have also the option of

importing innovations from abroad). Theoretically the need for such incentives is called for, or at least can be rationalized, on grounds of foregone social benefits resulting from an inadequate flow of innovations because of the lack of such incentives. Estimates to that effect are not available, but it is a theoretically demonstrable fact that in a competitive economy, including such an imperfectly competitive as is the U.S. economy, private investors in R & D leading to technological innovations, especially those favoring growth in productivity and the international competitiveness of the economy (including strong external value of the dollar), never capture all the benefits that accrue to the economy. In most instances, if not all, the social portion of the benefits greatly exceeds the private portion and frequently by a multiple factor (think, for example, about the social benefits or the "returns" to the development of artificial fertilizers and agricultural insecticides compared with the returns to the companies which developed these advances in agricultural technology, no matter how crudely both are calculated). Private investors invest in R & D only to the extent which is justifiable by their own expected (discounted) returns to the invested funds compared with all alternative investments and without any consideration of social benefits thereof. Other things being equal, the alternative investment opportunities to private investors, which at times might not be at all beneficial to society and occasionally might even be detrimental to society's interests, are as good as investments in R & D. The role of the incentives in question is, with as little fraction of the total cost as possible, to swing the

decisions in favor of R & D and thus assure the social returns of the total investment. Precise cost/benefit ratios of various potential schemes of such incentives cannot be readily furnished, but my crude calculations along these lines lead me to believe that sensible incentives would yield social benefits at a better than bargain price.

(4) Securing an optimum public investment in R & D in social infrastructure, including those relevant for society's "quality-of-life," and in civilian-market-oriented technological opportunities where for various reasons (such as industry fragmentation, excessive risk, etc.) the market forces and general incentives cannot assure an optimum level of effort. We have a number of mission-oriented agencies which have been trying to do this, but the attempts to "fill the gaps" of civilian markets have been rather haphazard (largely in response to "vested-interest" pressures, such as in agriculture and research for greater use of coal. R & D in desalinization of sea water and civilian nuclear technology are the only two areas in which vested-interest pressures played little or no role).

(5) Securing the proper industrial environment for the optimum utilization of new technology of domestic and foreign origin. By the proper industrial environment I mean adequate availability of venture capital; availability of incentives conducive for continuous modernization and new investment in plant and equipment which historically has been the chief vehicle for the diffusion of new technology; absence of institutional barriers against use of new technology (such as

restrictive work rules, several thousand local building codes, etc.); and the absence of heterogeneous standards and measurements. At this time we probably have fairly adequate Governmental incentives for the modernization of obsolete plant and equipment (new depreciation rate allowances and investment tax credits), but the restrictive work rules and the thousands of local building codes hinder the development and diffusion of new technology and the availability of venture capital is getting worse because of the rapidly increasing internationalization of U.S. capital markets and the apparently irreversible trend toward progressively higher interest rates.

(6) Securing the proper Governmental legal and regulatory posture with respect to the development and utilization of new technology, especially the absence of excessive barriers to cooperative R & D and utilization of the fruits thereof arising out of anti-trust laws and regulations, the absence of arbitrary pollution control and consumer protection type regulations, and the absence of arbitrary rate setting of utilities that inhibit the introduction and/or diffusion of new technology.

(7) Development and institution of patent policy that would tend to optimally stimulate the strive for development of new technology rather than to hinder it. At this time, there is considerable and healthy debate going on as to what kind of policy would be most appropriate for the purpose (short, say five years or so protection, or twenty or more years protection, that is, longer than we have today), but there also seems to be a disquieting trend of court verdicts underway

which imply the courts' questioning society's needs for any protection of property rights in the area of industrial and technological know-how on the part of private individuals and institutions.

(8) A Governmental procurement policy that would be conducive to the diffusion of new technology. Unlike in the area of defense and space the relative importance of such a policy for civilian technology is probably not great (except in the area of data processing and power generating equipment), but in a pragmatic concerted effort use must be made even of the forces that might only marginally contribute to the overall objective.

(9) Development and institution of policies that would assure optimum benefits of the country's technological effort for foreign trade and the balance of payments. There are a number of policies presently on the books whose effect seems to be the opposite. In the face of continued (and, at least in some important cases, increased) efforts by other countries to import advanced foreign technology in a naked form as rapidly as possible, on one hand, and still extremely powerful incentives for U.S. companies to export such technology also as rapidly as they can (see Tables 8 and 18), on another, it is practically unthinkable that the United States could counter the unfavorable trends of concern here, or even do much in other aspects of the overall technological policy, especially the institution of governmental incentives for an increase in private industrial R & D, without a drastic change in policies affecting transfers of technology in a naked form that are presently in force.

(10) Development of adequate and rationale safeguards against the ill use of new technology without stifling controls. As noted earlier, some of the rules and regulations we are promulgating now would seem to be based on arbitrary criteria. In the long run they might produce more harm than good.

(11) Institution of a system of "enlightened" timely publications which would inform the public about the social consequences of major technological changes--both beneficial and not so beneficial--and the available alternatives. The lack of such publications has probably been a factor in the growth and popularity of the "anti-technology movement" as well as actual delays in the diffusion of nuclear power-generating technology.

(12) Finally, there must be an institutional focal point of continuous responsibility within the executive branch of U.S. Government for the state of technology in the economy at large, statutorily empowered to initiate new policies as well as changes in old policies which became either inconsistent with the nation's needs or do not work effectively. At the present time there are about two dozen agencies having some responsibilities for the state of affairs in U.S. civilian technology, but there is no focal point. The prevailing view seems to be that this pluralism is the thing that "brought the country's technology" to the foremost of the world and that it will continue to serve the country well in the future.

In my judgment, the merit of this "pluralism" is even worse than the "merit" of the pluralism in the area of foreign economic policy formulation of up to a few years ago. The pluralism in the formulation of foreign economic policy worked "well" when the things and the country would probably have done well or better without the help of the many agencies which made the policies; however, when things got bad, the Government was forced to set up a focal point of responsibility (Council on International Economic Policy).

The heart of our "pluralism" in the area of technological policy formulation are (small) task forces, usually appointed for a short time to work out solutions to specific problems. The mechanism of task forces might and probably does work well when the problems the task forces are supposed to attack are narrow and technical in nature, the members of task forces are true experts in the problem area, and the members of task forces are adequately backed with staff. However,

- (1) when the problem areas which task forces are supposed to attack are broad and involve not only technological, but also social, economic and political considerations, and having both national and international objectives, and all of this is true in most technological problems facing the nation at large at this time; (2) when members of task forces are chosen not necessarily on the basis of their genuine expertise but largely on the basis of the need for agency representative or vested-interest groups and their availability, and this is true in most, if not all, cases; and (3) when members of task forces are not provided with back-up staff, but are supposed to do their own research

in the problem area and other staff work, and this is almost the rule in our system, then what such an adhocery system of task forces is likely to produce is, at best, a matter of chance.

Nor is the feebleness of the principal mechanism of our technological policy formulation all that there is to it. It is greatly compounded by a number of powerful institutional and other adversities, most notably the lack of effective continuity in the leadership of the agencies having formal responsibility for parts of the country's overall state of technology (the tenure of office of the people in question is usually far too short to acquire a proper understanding of the problems, let alone to promulgate policies that might be called for); the progressively rising budgetary constraints of the Federal Government; the dominance of short-term criteria in the Government's economic policy making and the lack of short-term political accomplishment appeal of most technological programs; the growth of extremely vocal anti-technology philosophy within the elite of American society; the pressures of conflicting private vested-interest groups; and the like.

I should like also to note that in contrast to the United States all other major industrialized countries have by now at least some sort of central point and continuity of Governmental responsibility for the state of technology in their economies at large, and most of them are quite elaborate and, evidently, quite effective. In short, by now the United States has an "entirely different world" to cope with than it used to have.

To me, the continuation of the kind of "pluralistic" system in the area of technological policy formulation as we have would be tantamount to a more or less continuation of current trends in our technology, and, of course, the kind of consequences as I outlined in the beginning of this section.

Each of the twelve strategic elements listed above might be instituted in a number of different ways. Defining and analyzing all the options that are available in this regard would require a major systematic effort which I have not been able to exert so far. However, in the context of my official and semi-official work I have given a considerable amount of fairly systematic thought as to how one might go about enhancing R & D for purposes of increased productivity growth and the international competitiveness of domestic industry and what would be the relative merits of the options that are available for the purpose. Enhancement of the R & D in question, I should note, might not be the most important element of the (comprehensive) national technological policy in terms of what it would actually accomplish, but it certainly would be the most costly as far as the Government's financial commitment is concerned, and, therefore, the policy opted for would probably prove the most difficult decision that the Government will have to make.

Options for Enhancement of Private R & D to Increase the Economy's Productivity Growth and the International Competitiveness of Domestic Industry

There are about a dozen distinct options that might in principle be used for the purpose. However, we are interested not only in their usability in principle, but also in what we could accomplish by using them, would their use be consistent with society's other objectives, etc. Prior to "naming names," therefore, I propose to take explicit notice of at least the principal criteria by which we must judge the usability and/or adaptability of the options that are available.

(a) The first and perhaps the foremost criterion is, of course, the size of the job which the policy or policies opted for must do. It is simply huge. This is implicit in the scope of what must be done in order to achieve the stated objectives: lifting up the technological level of literally tens of thousands of capital equipment items and/or developing thousands of entirely new equipment (to be used not only in industry proper, but also in Government and other "service" sectors of

the economy), thousands of consumer durables, hundreds of synthetic types of raw materials, etc. The huge job to be done is also implicit in the fact that by now the relative intensity of economically-relevant R & D effort of foreign countries, a key factor in international technological competitiveness, might exceed that of the United States, on the average, by at least 50 percent. In addition, foreign countries, largely because of their lower level of development, have easier access to advanced foreign technology, than we have. By crudely quantifying this advantage I estimate that our relative (R & D-equivalent) effort for purposes of economically-and international-competition-relevant technological advance is only about 40 percent as great as that exerted by other industrialized countries. This implies that if the U.S. seriously wanted to restore the international competitiveness of its industry, it should plan for at least a doubling of its R & D effort of concern here (not immediately, but eventually and the sooner the better. The lack of appropriately trained S & T manpower would prevent a large immediate expansion).

(b) There is no way to induce that big an expansion, if any, of the private economically-relevant R & D effort without substantial outlays, one way or another, of public funds. The outlays of such funds can be made only with the approval of Congress.

(c) Congress, as usual, will try to minimize outlays of public funds as much as possible and it appears to be out of the question that Congress would approve outlays of public funds that would be equivalent

to doubling the current level of the effort in question. The usability of any policy that the Government might opt for must be judged by the pull of private funds.

(d) Congress is unlikely to approve programs involving large outlays of public funds that might directly or indirectly benefit special groups, even "imaginary groups"--the kind that might be created in the process of setting "priority areas" of civilian-market-oriented technological development. Therefore, the more general the policies the Government would opt for the easier they will be to promulgate.

(e) The less bureaucracy build-up the policies opted for will require, the easier it will be "sold to public" and the easier it should be to promulgate it in Congress.

(f) The less bureaucratic control of the direction of technological development the policy or policies opted for will require, the more private initiative the policy will induce and the less resentment it will evoke on the part of private interests and on the part of Congress.

(g) Enhancement of new technology for the two stated objectives requires not only research, but also the development and commercialization of the fruits of research. The effectiveness in the latter depends on the availability of experimental base and marketing mechanism within the organization performing R & D, and/or at least strong ties of the R & D performer with outside organizations having the experimental base and marketing mechanism.

(h) R & D projects require highly sophisticated management. The less experienced the manager, the more errors and failures there will be.

(i) Governmental sponsorship of R & D involves extremely intricate proprietary issues with respect to which the Government has no clear-cut policy and it is not likely to have it soon. Therefore, the more direct Government's sponsorship of R & D, the more likelihood there will be for problems, litigation, etc.

(j) The policy or policies opted for should permit at least a crude periodic evaluation of their (long-term) results.

There may be some criteria, which I have not mentioned, that should be considered in evaluating the relative merit or usability of the options that are available in principle, but I do not think they would change the general propositions which I make by considering only the ten listed above. With this in mind, let us see what can be used.

(1) Naturally the first option that comes to mind is "beefing up" the R & D level at universities via Government contracts or tax credits to private companies sponsoring the "beefing up." Universities are known to have made great contributions to our defense and space effort, and occasionally contributed to the development of civilian technology (e.g., computers at the University of Pennsylvania, and the numerical control of machine tools at MIT). The advantages of this route would be a readily available and fairly good management of the projects at the performer level; the program would yield some financial help to the universities which they badly need; the policy would easily render

itself to periodic evaluation of its results; and Congress would probably approve it if it were convinced that this is the viable route. The limitations of this route, however, would simply be overwhelming: the universities most probably would not want to expand their R & D facilities much beyond what they presently do, let alone by as much as the "job to be done" needs; the universities have little experimental bases for industrial technology and none whatsoever in marketing experience and their ties with industry are very weak and are not likely to become much stronger no matter what the Government would do (because of the "natural" striving for independence on the part of professors); the proprietary problems would probably be stupendous; in case contracts would be the method, the Government bureaucracy administering the program would zoom; and the cost of the expanded R & D effort would be 100 percent, or actually more because in the expansion some if not many "technological opportunities" would be tackled which private industry would have tackled in due course with its own funds anyway. All things considered, this route is not the kind that could accomplish much or one that the country could opt for (note that this judgment refers to industrial-type of R & D and not to basic research).

(2) As a second option, we might think of expanding the R & D effort via federally-funded research centers and (largely federally-funded) "nonprofit-making" private research organizations. The advantages in following this route would be the readily available expert project managers and in the future the long-term results would be fairly easy to assess. The disadvantages, however, would be almost as

overwhelming as with the universities, plus--there would be strong resentment to this route on the part of private enterprise and Congress would probably not approve it because of the potential growth of Government's control of civilian technology.

(3) The third option is to support small (independent) innovative entrepreneurs via contracts and/or cost sharing. This option, I should note, is quite popular with many economists and Government officials,⁷⁰ due, in large measure, to an idea promulgated by a 1967 Department of Commerce study⁷¹ that the bulk of the technological progress of the country has been generated not by large corporations, but by small entrepreneurs and/or independent inventors. Most of the information on which this idea was based, however, referred to the late 19th century and early part of the 20th century. Since World War II, as shown in Table 22, the small innovative entrepreneurs' contribution to the country's overall technological progress might be equated to the polaroid camera, xerox copying device and a few inventions of Texas Instruments if Texas Instruments could be considered as a "small entrepreneur." In following this route for the purpose at hand the

⁷⁰Cf., for example, Economic Report of the President, 1972, Chapter 4.

⁷¹U.S. Department of Commerce, Technological Innovation: Its Environment and Management, Washington, D.C., 1967, Chart 13, p. 18.

TABLE 22. TECHNOLOGICAL BREAKTHROUGHS ORIGINATED IN THE UNITED STATES SINCE WORLD WAR II

| Breakthrough | Inventor and/or Sponsor | Year |
|--|---|--|
| Streptomycin | Selman A. Waksman/Merck & Co. | 1943-1944 |
| Polio vaccine | Jonas E. Salk/University of Pittsburgh | 1954 |
| Dithiocarbonate fungicides (Synthetic organic fungicides) | DuPont, Rohm and Haas | 1945 |
| Polyamides (synthetic fiber) | DuPont | 1935 ^a / 1939 ^b / |
| Acrylic (synthetic fiber) | DuPont | 1941-1947 ^a / 1950 ^b / |
| Electronic transistor | Bardeen, Brattain and Shockley - Bell Labs | 1947 |
| Square-loop ferrities | Albers-Schoenberg/MIT, General Ceramics | 1949-1950 |
| Integrated electronic circuits | Texas Instruments, Fairchild & Westinghouse | Early 1950's |
| Electronic telephone switching gear | Western Electric | 1955 |
| Satellite communications systems | AT&T, TRW, Hughes Aircraft/ Department of Defense | 1958 |
| Digital computers | University of Pennsylvania/ Army; MIT, Remington Rand | 1945-1951 |
| Analogue computers | National Bureau of Standards, Reeves Instruments, Johns Hopkins-Curtis Wright | 1945-1946 |
| Magnetic "bubble" memories | Bell Labs | 1966 ^a / |
| Nuclear magnetic resonance spectroscopy | Bloch & Hansen | 1945 ^a / 1949 ^b / |
| Infra-red spectroscopy | Varian Associates | World War II ^a / 1946 ^b / |
| Laser | American Petroleum Institute Perkin-Elmer ^b | 1960 |
| Turbo-generators working with super-critical pressures and temperatures of steam | Bell Labs, Hughes Res. Lab | 1957 |
| | Babcock-Wilcox | Late 1950's |
| | GE, Westinghouse | |

TABLE 22. TECHNOLOGICAL BREAKTHROUGHS ORIGINATED IN THE UNITED STATES SINCE WORLD WAR II--Cont.

| Breakthrough | Inventor and/or Sponsor | Year |
|---|---|---|
| Nuclear reactors for electric energy generation | GE, Westinghouse/AEC, Navy | 1954 |
| Thin tin plate | U.S. Steel | Late 1950's |
| Taconite processing | E.W. Davis ^a /University of Minnesota Reserve Mining | 1912-1922 ^a / 1955 ^b / |
| Numerical control of machine tools | MIT/Cincinnati Milacron and Giddings & Lewis | 1954-1955 |
| Electromilling of metals | Anocut Corp. and Elox Corp. | Early 1950's |
| High energy rate forming of metals | USI Clearing and Verson Allsteel Press | 1955 |
| Vertical take-off aircraft | Bell Aircraft-NASA, Convair-Navy | Mid 1950's |
| Continuous mining machines | Joy Mfg. | 1948 |
| Synthetic diamonds | GE | 1955 |
| Fiber Optics | Armour Research | 1960 |
| Deinking of used newsprint | Garden State Paper Co. | 1952 |
| Tape controlled electrosetting machines | Intertype | 1950 |
| Mechanical color separation | Printing Development Inc./RCA | Early 1950's |
| Shadow-mask color TV picture tube | RCA | 1947 |
| Polaroid photography | Edwin Land | 1947 |
| Xerography | Chester Carlson/Battelle Dev. Corp. | 1937 ^a / 1946 ^b / |

^a/ Development^b/ Commercialization

Source: Compiled by the Department of Commerce

advantages would be the potential intensification of competition and political "sex-appeal"--hence, it would probably be easier to promulgate than some other routes if Congress were convinced that this is the proper route. However, in terms of the criteria listed above, the disadvantages of this route would not be much smaller than with universities and federally-funded research centers: only a trickle of the needed expansion of R & D could be accomplished; most small enterprises generally lack the experimental bases and marketing expertise; whatever expansion would be achieved the Government's cost would not be much less than 100 percent because of the generally weak financial position of small enterprises and, in following this direct-support route, the Government would finance things that business at large would do in due course with its own funds; and there would be many proprietary problems. All things considered, I do not think this is a viable option, especially if it were used as the sole route.

(4) The fourth option is to expand the R & D via contracts to and/or cost sharing with firms having excess R & D facilities and managerial talent due to cut-backs in defense and space programs. The advantages of this route would be utilization of idle R & D facilities (originally funded by Government) and experienced management and the results of the program could probably be kept track of for future assessment. However, the disadvantages would be that the projects would be carried out with a defense-and space-type R & D philosophy, since most of the firms in question are heavily indoctrinated and still predominately oriented toward defense-and space programs markets; the

firms generally lack marketing expertise in nondefense markets; the cost of the expansion to the Government would tend to be close to 100 percent or more because many things would be financed with public funds which private business at one time or another would do itself; proprietary problems would plague the program; the route would require a large Governmental bureaucracy to administer; and the public, and perhaps Congress, would look at these programs as a "special interest" enterprise and possibly even as a "disguised" military-industrial effort.

(5) We might also try to expand the R & D in question via contracts and/or cost sharing with manufacturers of "capital goods," as some advocate. The advantage of this route would be experienced management of projects, since capital goods producers do quite a bit of their own R & D; the manufacturers of capital goods, in the aggregate, are aware of the current state of U.S. technology in great detail and should have some insight as to what are the most promising opportunities for further progress; they also have the experimental bases as well as marketing expertise; and the results might fairly easily be assessable in the future if proper records were kept for the program. However, in following this route the technological opportunities in the area of consumer durables, raw materials, perhaps energy, and other technology not entering the economy via existing capital goods would be left out; in contact arrangement, the projects would not be carried out by the most talented manpower (the most talented would probably be employed on the firms' own projects); in many instances (probably all most

promising projects) the Governmental contacts and/or cost sharing arrangements would substitute for the industry's own effort (at one time or another); the route, as others of a direct-support nature, would require a large bureaucracy to administer the projects; the cost of the expansion to the Government would be large; proprietary problems would plague the program; and the public, and perhaps Congress, would probably look upon it as a "special interest" enterprise.

(6) The sixth option is to expand the R & D via contracts to and/or cost sharing with all kinds of business firms having demonstrable capability to do research, developing and marketing new technology.

The advantages and disadvantages of this route would be essentially the same as with the manufacturers of capital goods (option 5) except that the technological opportunities would be tackled on a more comprehensive scale.

(7) ~~One~~ might also try to do the job by establishing a national foundation for industrial R & D which would disburse a certain magnitude of appropriated funds in the form of grants in accordance with projected cost/benefit ratios or other criteria that it might develop for the purpose. The advantage of this route would be that it would assure the availability of funds for really meritorious proposals. But in many instances it most certainly would be substituting public funds for private funds, it would require a large bureaucracy to administer the disbursement of grants, and the extent of enhancement of the country's R & D effort in question, that is, above what market

forces would generate without such a foundation, might be nil, if any, if the annual appropriations for the purpose were not sufficiently large.

(8) It might also be possible to enhance the country's R & D effort in question via interest-free or low-interest Governmental loans to qualified ("bona fide") performers to be disbursed by a specially established bank. The net effect of such loans would be the subsidization of R & D in question by the amount of the difference between the interest rate charged by commercial banks and the charges, if any, by the bank. The program would probably generate more R & D than the market forces would do without it, especially in the area of "big ticket" projects of large corporations, but on a whole not necessarily much more, because of the relatively small "marginal" incentives, and at a substantial cost to Government because the loans would have to be available not only to those performers who would not do the R & D unless such loans were available, but also to those who would do it anyway. In addition, the bank in question would have to be manned by a large staff of experts who could make a larger contribution to the country's R & D effort in question by doing actual R & D rather than administering the Government's program.

(9) One might also try to enhance the R & D in question via the

British route,⁷² namely through the establishment of a publicly funded and profit-oriented National Research and Development Corporation which would contract for research and/or buy readily available patents for new know-how from private individuals and companies that is of potential benefit to the objectives but is unlikely to be developed and commercialized by private interests; develop or contact for the development of the know-how; and sell the developed know-how to private interests for commercialization on a royalty basis. The advantages of this route might be a fuller utilization of the country's innovative potentialities, especially of that residing in "lone wolves"; fostering of small innovation-oriented companies (and, hence, fostering competition); and the results of the program could be assessed fairly easily in the future. Its disadvantages, however, would also be formidable: the initial public cost of the innovations would tend to be close to 100 percent; the profit motive would undoubtedly push the corporation toward most promising innovations which in due course private interests would develop anyway and, hence, there would be at least some

⁷²In addition to Great Britain, this method is being experimented with by France, Japan, the Netherlands and, in some form, other countries.

substitution of public funds for private funds; and Congress would probably never appropriate sufficient funds to make the program as big as the country needs. This route might be good, or even ideal, for small and/or countries still at a low level of technological sophistication (and, hence, relatively narrow scope of developmental options), but for as big and technologically as developed country as is the United States this route would probably not do much good.

(10) There is also the option of enhancing the R & D in question via speical tax incentives (credits) or equivalent cash payments to performers with no tax liability for all private investments in R & D that would meet certain criteria consistent with the policy objectives (the criteria to be defined in the legislation). The economic objective (and probably the results) of such incentives would be to subscribe to a part of the ever present risk of privately conducted R & D and thus induce private investors to undertake more projects than they would undertake without such incentives.

The principal advantage of this route would be a maximum participation of private funds in the expansion of the effort and that with a proper strength of the incentives (size of the tax credits) it would probably induce an optimum expansion of the R & D effort (which I would define as that consistent with the full employment of qualified S & T manpower). Also, in following this route the required bureaucratic machinery to administer the program would be minimal (if the eligibility of the projects for the incentives were clearly defined in the law);

there would be few proprietary problems (the proprietary rights to the inventions would automatically go to private investors); and the programs would be strictly national rather than a "special interest" enterprise.

The disadvantages of this route would be some duplication of the same R & D projects in several firms; it might be conducive to a greater rate of R & D project failures than some of the direct approaches because of the inexperience of some newcomers to R & D activity which the program would induce; and its effectiveness would be difficult to ascertain with any degree of precision. In a technical sense the results of these disadvantages might be labeled as "social waste." In such activity as R & D, however, some duplication (essentially the same projects in various forms) is probably desirable since it would tend to enhance competition in the economy and the excess could be kept at a minimum by some procedural devices that could be built-in into the scheme (such as certification of the eligibility of projects for incentives in the process of which the excessive duplication might be minimized), and the tendency to greater rates of project failures because of inexperience of "newcomers" might at least in part be offset by the heavier financial participation of private funds and the absence of failures induced by errors of bureaucrats.

This route, however, would have one disadvantage that could not be overcome: by subscribing to a portion of the cost of all R & D in question it would substitute public funds for some portion of private funds that are being invested in R & D by private interests anyway and,

therefore, the kind of increase in the R & D effort that the country needs would probably be very costly to the Government if this route were followed.

(11) Instead of providing tax incentives or equivalent cash payments for all R & D in question, however, we have also the option of providing tax incentives or equivalent cash payment for only the incremental R & D in question (above a certain historical base level, including a zero level for those who have never performed R & D). The advantages and disadvantages of this route would be the same as with tax incentives for all privately performed R & D in question (option #10) except that, and this is of paramount importance, by subscribing to a portion of the cost of incremental R & D rather than to a portion of all of it there would be little, if any, substitution of public funds for private funds and, therefore, the optimum expansion of R & D via this route would be a lot less costly to the public than that achievable by any other route.

(12) Finally, there is the option of trying to stimulate the flow of successful innovations that meet certain criteria consistent with the objectives of the program in question, that is, to stimulate the output of R & D rather than the input. For that purpose ~~one~~ might try to devise a system of tax credits or equivalent cash payments for a portion of the R & D cost leading to commercially successful innovations.

Compared with the incentives for the enhancement of inputs (options #10

and 11), the advantage of this approach would be that only the successful projects would be rewarded rather than to subscribe to successes as well as failures. Rationalizing rewards to successes is much easier than rationalizing the rewards of failures and, therefore, this approach, in principle, has considerable attraction. The process of successful innovations is so complex, however, that I doubt that it is possible to design a program in line with this idea, and even if it were possible that it would work. In order to design such a system one would have to define the cost of successful innovation in a meaningful (business-wise) and unambiguous way and this is, at best, next to impossible. For example, I am told that nowadays a discovery of any new functional chemical (such as pesticides or lubricating oil additives) requires the screening of literally thousands of candidate chemicals. Would the R & D cost of the new chemical--

(a) include only the cost of the R & D that directly led to the chemical's discovery, or

(b) would it also include the cost of screening the thousands of candidate that did not work? If the decision is made in favor of (a), the question arises whether this would be realistic, would this cost be ascertainable (for tax credit purposes) and whether or not the incentives thus designed would do any good. On the other hand, if the decision is made in favor of (b), and the probability is that this is how the performers would look at the cost of a successful chemical, the question is what would we subscribe to--the cost of R & D or the

cost of successful R & D. It appears to me, therefore, that, notwithstanding the attractiveness of the idea in principle, it is not very practical.

To me, the twelve options listed above more or less exhaust the range of theoretical possibilities of how one could go about trying to enhance R & D. All of them have certain advantages as well as disadvantages. Not one of them is the kind that we could grab without further questions being asked. It seems to be more than apparent, however, that the next to the last option--tax incentives for incremental R & D directed toward stated objectives--is the most promising, most equitable and, indeed, the most sensible given the size and the structural peculiarities of the U.S. economy. There are those who despise the very thought of this idea, but to me, considering the kind of economy and Governmental institutions that we have, this route appears, despite all the limitations, to be simply a pragmatic inverse of our going to the moon.

I trust that I made it adequately clear in the discussion of policy needs, however, that the adoption of a program for the enhancement of R & D, whatever route might be decided upon, is not all that this country requires--it would be only a small fraction thereof. What the country needs is a comprehensive national technological policy.

APPENDIX

SOURCES OF INFORMATION AND OTHER EXPLANATIONS REGARDING THE ESTIMATES OF COMPARATIVE LEVELS OF PRODUCTIVITY AND DOLLAR COST OF MANUFACTURING IN THE U.S. AND THE OVERSEAS FACILITIES OF U.S.-BASED MULTINATIONAL COMPANIES SET FORTH IN TEXT TABLE 8.

1970:

Item 1. Derived from data in U.S. Department of Commerce, Bureau of Economic Analysis, Special Survey of U.S. Multinational Companies, 1970, November 1972 (referred to hereafter as the Special Survey).

Item 2. Same as Item 1.

Item 3. Assumed to be the same as the relative dollar cost of raw materials, energy and services net of multiple counting consumed in the year per employee. The rationale for this assumption is that raw materials and energy sources are generally internationally traded goods and their relative dollar prices (per unit of physical measure) tend to be fairly similar the world over. The relative dollar price of services (largely transportation, communications and wholesale of materials) might differ, but their shares in the respective totals are small (less than 10 percent). Data on the dollar cost of materials, etc., which includes multiple counting, are from the Special Survey. The figures posted in the table assume that the multiple counting in the cost of materials, energy and services in all the regional aggregates of U.S. companies' facilities, except Canada, amounts to about 48 percent of the totals in question, which is to say, about the same as in total manufacturing in the United States in 1963 and 1958. I equate multiple counting of cost of materials, etc., of an industry with its purchases of intermediate inputs (all inputs other than value added) from within the industry itself. This proportion is readily ascertainable from, respectively, BEA's input/output table for 1963--Survey of Current Business, November 1969; and Michael D. McCarthy, On the Aggregation of the 1958 Direct Requirements Input-Output Table, The Brookings Institution, ECMOD RM 65-2, June 1965, Table I, duplimate.

The use of the U.S. ratio of multiple counting in these calculations is predicated on the assumption that the technological process composition and sourcing of materials, components and subassemblies used by the foreign subsidiaries of U.S. manufacturing companies is essentially the same as in the United States. If these were the same as they seem to prevail in the total manufacturing industries of countries in which the subsidiaries operate, which I infer from input/output tables of about half a dozen of foreign countries relevant for this analysis, the proportion of multiple counting in the cost of materials, etc. of the subsidiaries in Europe might be some 5 percentage points smaller and of those in Japan some 5 percentage points or so greater than I postulate, but the average of all the subsidiaries, at least in the developed countries other than Canada, would be about the same.

Because of the extensive specialization in certain processes and parts manufacture for both U.S. and Canadian markets, the interchange of parts with U.S. plants as well as resales of complete products produced in the U.S. plants, especially in the automobile industry, the extent of the multiple counting in the cost of materials of the aggregate of the Canadian subsidiaries of U.S. companies must be much higher than in the total of U.S. manufacturing industry, but the extent of this excess is not directly determinable. The figure posted in the table assumes that the Canadian subsidiaries' dollar cost of raw materials, etc. per employee relative to that of the U.S. counterpart plants is about the same as the cost of materials, etc. in U.S. dollars per employee expended in the whole Canadian manufacturing industry in making products of its own manufacture relative to the cost of materials, etc. expended per employee in the U.S. manufacturing industry. Inasmuch as the bulk (close to two-thirds) of the total Canadian manufacturing industry, in terms of value of output, consists of U.S. subsidiaries, but whose value of output amounts to less than 10 percent of that of the total manufacturing industry in the United States, this assumption seems as sensible as one can make. The result of this estimating procedure implies that the proportion of multiple counting in the cost of materials, etc. of the aggregate of the Canadian subsidiaries of U.S. firms is about 46 percent greater than that in the total manufacturing industry in the United States. I obtain this greater proportion for all transactions of Canadian manufacturing industry, including intraplant shipments with the United States, by extrapolating the relevant input/output coefficients in the Canadian input/output tables for 1949 and 1961 to 1970. This, of course, does not prove the accuracy of my calculations, but it does imply that the assumption which I used in making the estimate is not "wild."

The reason for calculating relative productivity levels on the basis of the cost of materials, etc., net of multiple counting, per employee rather than in some alternative manner, I should explicitly note, is twofold. First, considering all the readily available information this method represents the most straight forward approximation of the comparative physical output per employee, especially in the case of Canada, that one can think of. Secondly, and even more importantly, the use of the cost of materials, etc. net of multiple counting, is conducive to much more accurate analysis of the comparative cost levels by type and analysis of the probable impact of devaluation of the dollar on the total dollar cost of manufacturing in foreign countries, set forth, respectively, in Items 4 and 7, than would be possible by using cost data inclusive of multiple counting. The use of the cost data inclusive of multiple counting would lead to a substantial understatement of the impact of the devaluation on total cost abroad, because of the exaggerated weight that I would have to assign to the cost of materials in all countries but most of which Europe and Japan import from either LDC's, the United States or Canada and where the currency realignment made their raw materials relatively much cheaper to Europe and Japan than before the realignment.

I must hastily also note, however, that except for Canada roughly the same relative levels of comparative productivity as posted in the table may be

obtained from estimates of relative sales per employee inclusive of multiple counting by blowing up the indices posted in Item 2a by the implicit price level ratios of the foreign countries in question relative to those in the United States which might safely be assumed to be the relative price levels at which the U.S. companies operating in various countries sell their products. The indices of the relative price levels I refer to are derivable from the extrapolations of relevant comparisons made by Milton Gilbert and Irving Kravis in the 1950's for the United States and selected European countries (Comparative National Products and Price Levels, OEEC, Paris, 1958), the German estimates of comparative cost of living in most major countries in the world (published annually, with some lag, in Statistisches Jahrbuch für die Bundesrepublik Deutschland, Section "Internationale Übersichten"), extrapolations of similar Japanese, though much less voluminous, estimates (see source cited in Table 7), and other estimates of a similar nature, including, most notably, estimates of various countries' comparative real incomes and/or gross domestic products based on physical measures of output vis-a-vis values in individual countries currencies converted into U.S. dollars by means of official exchange rates (see, e.g., Wilfred Beckerman, International Comparisons of Real Incomes, OECD, Paris 1966; and Alan Heston, A Comparison of Some Short-Cut Methods of Estimating Real Product Per Capita, University of Pennsylvania, 1971 (a duplimate paper presented at the Twelfth General Conference of the International Association for Research in Income and Wealth, Ronneby, Sweden, August 30 - September 4, 1971)). Based on all of this information it seems safe to assume that as of 1970 the European across-the-board prices of comparable goods and services were about 80 percent of the U.S. level; in Japan, 75 to 80 percent; and in LDC's, 70 to 75 percent. Applying these indices of relative price levels to the estimates in Item 2a implies that in the EEC the U.S. companies' sales per employee, adjusted for the differences in price levels at which the companies sell their products, amounted to about 83 percent of these in the United States ($66 \div 80 \times 100$); in Japan to 103 percent ($80 \div 77.5 \times 100$); and in LDC's to about 64 percent ($45 \div 70 \times 100$). These alternative estimates are practically identical with those posted in the table (Item 3).

Item 4a. Obtained by dividing the relative dollar cost per employee (Item 1) by the relative physical output per employee (Item 3) and multiplying the quotient by 100.

Item 4b. Obtained by dividing the relative cost of depreciation and (net) interest per employee by the relative physical output and multiplying the quotient by 100. For 1970 the Special Survey gives data only for the cost of depreciation. For 1966, the same Survey contains data on the cost of interest in the foreign affiliates, but not for the consolidated sample, and, hence, not for their domestic facilities. This was estimated on the basis of the percentage relationship of the cost of net interest of all manufacturing corporations to their total liabilities in that year as reported in the IRS, Statistics of Income 1966, Corporation Income Tax Returns. Thus obtained estimates of the costs of interest in all regional aggregates of the companies' facilities in 1966 were extrapolated to 1970 in accordance with changes in the total liabilities of the respective regional aggregates of the companies' facilities, given in the Special Survey, and changes in interest rates as reported in publications of the International Monetary Fund and the Bank for International Settlements.

Item 4c. Obtained by dividing the relative cost of materials, energy, etc., net of multiple counting per employee by the relative physical output per employee and multiplying the quotient by 100. The source of information and the procedure used in estimating the relative cost of materials, etc., net of multiple counting is explained in Item 3 above.

Item 4d. Represents the respective dollar-weighted sum of Items 4a, 4b and 4c.

1973:

The estimates represent extrapolations from 1970 in accordance with the probable dynamic changes in the relevant variables, and changes in exchange rates, including the results of "floating," which occurred between December 1971 (Smithsonian Agreement) to June 29, 1973. Specifically, the estimating procedures were as follows:

Item 5. For all countries except LDC's--extrapolated from 1970 in accordance with the 1966-1972 average annual growth in compensation per man-hour in total manufacturing industries of the respective countries in their own currencies (as reported by the U.S. Bureau of Labor Statistics (Monthly Labor Review, August 1971, and subsequent press releases), with subsequent adjustment for changes in the exchange rates in December 1971 - June 29, 1973. For LDC's the growth in the companies' pay per employee in dollars is assumed to have continued at the same rate as in the 1966-1970 period, and reported in the Special Survey, subject to adjustment in the exchange rates. The adjustments for changes in the exchange rates were as follows:

| Country or Region | Percentage Change in U.S. Dollar Cost of Foreign Currencies from Dec. 1971 to June 29, 1973, Percent |
|---------------------------------------|---|
| Canada | + 0.9 |
| EEC | +38.0 |
| United Kingdom | + 7.7 |
| Other Europe | +31.4 |
| Japan | +38.6 |
| Australia, New Zealand & South Africa | +20.7 |
| All Developed Countries | +21.0 |
| LDC's | + 2.8 |
| All Foreign Countries | +16.4 |

For the regions the estimated changes represent 1972 U.S.-import-weighted averages. The data for individual countries were furnished by Commerce's Bureau of International Commerce, International Trade Analysis Staff (Omnitab Exchange Rate Model).

Item 6. United States - growth in accordance with the growth in output per manhour in total manufacturing: 1970-1972, BLS estimate; 1973, assumed

to be the same as in the first quarter of 1973 over the first quarter of 1972 (BLS estimate).

Canada, EEC and the United Kingdom--growth in accordance with the growth in output per man-hour in total manufacturing of the respective countries: 1970-1972, BLS estimates; 1973, the same annual growth over 1972 as the average in the 1966-1972 period (BLS estimates).

Japan--growth in accordance with the growth in output per man-hour in total manufacturing: 1970-1972, BLS estimates; 1973 growth assumed to average about 8.6 percent over 1972 or 25 percent lower than the average in the 1966-1972 period.

LDC's--1970-1973 growth assumed to be proportional to the growth in dollar payroll per employee.

Item 7a. As in Item 4a, obtained by dividing Item 6 by Item 5a and multiplying the quotient by 100.

Item 7b. Estimates analogous to Item 4b. For each country the dollar cost of capital services per employee through 1973 is estimated on the assumption that the growth in these costs relative to implicit growth in productivity continued at the same rate as between 1966 and 1970 (Special Survey).

Item 7c. Estimates analogous to Item 4c. From 1970 to 1973 the cost of materials, etc. per employee in each country's currency is assumed to have grown 13 percent faster than the growth in physical output per employee (productivity), as in the United States in the 1966-1971 period, and the results converted into U.S. dollars in accordance with exchange rates as of June 29, 1973 (see Item 5), depending on where the materials, etc. and what proportion of the total originate--domestic or imported. All of the imported raw materials and energy sources of the European countries and Japan are assumed to originate in either LDC's, the United States or Canada. In regard to the relative reliance on imported raw materials (imported raw materials as a percent of the total consumption of raw materials, energy and associated services) the following assumptions were used:

| Country or Region | Proportion of Imports in the Total Cost of Materials, Energy and Services | |
|-------------------|---|------|
| | 1970 | 1973 |
| United States | 10 | 11 |
| Canada | 20 | 20 |
| EEC | 47 | 58 |
| United Kingdom | 52 | 58 |
| Japan | 66 | 76 |
| LDC's | 0 | 0 |

For developed countries these percentages are based on crude estimates of trends in the actual reliance of the respective economies as a whole between 1962 and 1970. These estimates are given in Table A-1.

LDC imports of raw materials from U.S. and Canada are arbitrarily assumed to be zero. Whatever error there may be in this assumption, it is inconsequential for the calculations. Except for Canada the results of these calculations would have been almost identical had the individual countries' 1966-1970 trends in growth of cost of materials, etc., per employee relative to the growth in productivity, estimatable from the Special Survey, been used rather than the 1966-1971 U.S. ratio.

Item 7d. Sums of Item 7a through 7c weighted with the relative dollar values.

TABLE A-1. COMPARATIVE DEPENDENCE ON IMPORTS OF EXTRACTIVE MINERALS AND FUELS,
SELECTED COUNTRIES, 1962 AND 1970

| Year and Country | COMPOSITION OF SUPPLY, \$ MILLION | | | | SELECTED RATIOS | | |
|-------------------------------------|---|---|--|---|---------------------------------------|--|--|
| | Approximate value of domestic output of extractive minerals, crude petroleum and gas, ^a producers' market prices | Exports of extractive minerals, and crude petroleum, f.o.b. | Imports of extractive minerals, and crude petroleum and <u>net</u> imports of refined products and gas f.o.b. ^b | Apparent domestic consumption of extractive minerals and fuels, incl. change in stock and losses, ^c producers' market prices | Imports as percent of domestic output | Imports as percent of domestic consumption | Ratio of foreign countries imports of extractive raw materials and fuels per \$ worth of GNP relative to the U.S. U.S.=1.0 |
| <u>1962:</u> | | | | | | | |
| United States..... | 20,643 | 251 | 2,203 | 22,586 | 11 | 10 | 1.0 |
| France..... | 1,748 | 156 | 981 | 2,573 | 56 | 38 | 3.3 |
| West Germany..... | 3,065 | 56 | 767 | 3,776 | 25 | 20 | 2.0 |
| Benelux ^d | 659 | 107 | 686 | 1,237 | 104 | 55 | 5.0 |
| Italy..... | 383 | 51 | 620 | 952 | 162 | 65 | 3.1 |
| Common Market, total ^d . | 5,854 | 370 | 3,054 | 8,538 | 52 | 36 | 3.0 |
| U.K..... | 2,953 | 66 | 1,426 | 4,313 | 48 | 33 | 3.9 |
| Japan..... | 1,360 | 4 | 1,479 | 2,835 | 109 | 52 | 5.0 |
| Canada..... | 2,161 | 966 | 472 | 1,667 | 22 | 28 | 3.0 |
| <u>1970:</u> | | | | | | | |
| United States..... | 26,666 | 663 | 2,847 | 28,850 | 11 | 10 | 1.0 |
| France..... | 1,693 | 158 | 2,198 | 3,733 | 130 | 59 | 4.2 |
| West Germany..... | 3,370 | 129 | 2,471 | 5,712 | 73 | 43 | 4.6 |
| Benelux ^d | 901 | 391 | 1,523 | 2,033 | 169 | 75 | 8.0 |
| Italy..... | 708 | 68 | 1,571 | 2,211 | 222 | 71 | 4.8 |
| Common Market, total ^d . | 6,672 | 746 | 7,763 | 13,689 | 116 | 57 | 4.9 |
| U.K..... | 2,398 | 165 | 2,453 | 4,686 | 102 | 52 | 5.5 |
| Japan..... | 1,967 | 11 | 5,918 | 7,874 | 301 | 75 | 8.0 |
| Canada..... | 4,260 | 2,269 | 579 | 2,570 | 14 | 23 | 2.4 |

Table A-1, Continued

^aThe value of domestic output of these products is defined as the value added plus the cost of raw materials, fuels, electric energy and other services net of multiple counting consumed in the production of these products. This concept is consistent with the content of exports, imports and consumption. The dollar values for foreign countries are derived by converting the estimates in national currencies into dollars by means of official exchange rates in force at the respective years. To the extent by which relative dollar price levels of the products in question differ from country to country, the use of official exchange rates for the purpose yields only rough approximations rather than accurate measures.

^bForeign import data are only reported in terms of the "cif" concept. The "fob" figures posted in the table assume that the foreign countries' "cif" (cost of insurance and freight) represent 8 percent of the total, or some 20 percent less than the Bureau of the Census estimated "cif" of U.S. imports in question. The lower "cif" rate of foreign imports is suggested by the well-known fact that foreign freight rates are substantially lower than U.S. rates.

^cApparent domestic consumption is defined as domestic output plus imports minus exports.

^dThe trade data for the Benelux and Common Market countries include trade within these entities. This tends to overstate their net imports and relative dependence on imports but probably not significantly because the bulk of these countries' imports in question do not originate in the Benelux or Common Market countries.

Sources: U.S. Department of Commerce, OECD, UN, and individual country data.

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